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ABSTRACT

This dissertation examined the effects of early participation of classroom teachers in the development of mathematics curricula, and familiarization of teachers with new mathematics curriculum on the teachers' attitudes toward the introduction of new curricula and its implementation. Past curriculum development efforts and studies of the implementation process were reviewed, and problems of organizing workshops analyzed. Participating were mathematics teachers from teachers' colleges in three Nigerian states. A 50-item questionnaire was given to 96 teachers before and after they attended a workshop designed to familiarize them with the new curriculum and solicit their suggestions, and to 209 teachers who did not attend. The questionnaire measured attitude toward curriculum change, previous participation in curriculum development, and knowledge about the new curriculum. The workshop group showed significant gains for attitude toward curriculum change and knowledge of the new program, while the control group showed no significant change in knowledge and a significant decline in attitude. A third administration of the instrument showed slight, non-significant declines in attitude, knowledge, and participation scores of the workshop group. Few significant interrelationships were found between the main variables and teacher qualifications, experience, and nationality. Suggestions for future familiarization efforts are given. Appendices include the letter of request, a list of teachers' colleges, the questionnaire, and a workshop evaluation form and program. (MNS)

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TEACHER PARTICIPATION IN MATHEMATICS CURRICULUM DEVELOPMENT AND IMPLEMENTATION IN THREE NORTHERN STATES OF NIGERIA

BY

LAWRENCE HOYT SHIRLEY

A thesis submitted to the Postgraduate College
Ahmadu Bello University

in partial fulfilment of the requirement for the
degree of Doctor of Philosophy
in

Curriculum and Instruction(Mathematics Education)

Department of Education
Faculty of Education
Ahmadu Bello University
Zaria, Nigeria

March 1984

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To all, thank you.

— L. H. S.

December 1983

ABSTRACT

This study examines the effects of (a) early participation of classroom teachers in the development of mathematics curricula, and (b) familiarization of teachers with new mathematics curricula, on the teachers' attitude toward the introduction of new curricula, and more generally, on the successful implementation of new mathematics programmes.

The study is organized into four complementary areas of research: (a) a historical review of past mathematics curriculum development efforts, (b) a survey of theoretical studies of the process of curriculum implementation, (c) a statistical analysis of survey and experimental data on teachers' attitudes toward accepting a new mathematics curriculum, and (d) a compilation of the experience of being involved in the process of implementing a new mathematics curriculum and especially of organizing curriculum familiarization workshops for teachers.

The historical study considers the development of mathematics curricula, mainly in the twentieth century, including discussion of the introduction of "modern mathematics" programmes in various countries. Recent mathematics programmes in West Africa, and particularly in Nigeria, are given special emphasis, including the newest mathematics curricula for all levels of schooling in Nigeria. Throughout the historical study, the many forces acting on the development of curricula and the role

of classroom teachers in the design and implementation of the programmes receive special attention.

The survey of theoretical studies of curriculum implementation includes discussion of early attempts at organizing this complex field, various models which have been proposed to describe the processes of disseminating and gaining acceptance of educational innovations and new curricula, and case studies of the problems of implementing new curriculum programmes. As in the historical study, special consideration is given to the participation of teachers in curriculum design and the need for teacher training.

The statistical study used a fifty-item questionnaire instrument to measure (a) attitude toward accepting a new curriculum, (b) amount of previous participation in curriculum development, and (c) factual knowledge of the content, philosophy, and development of the newest syllabus in mathematics. The research is a case study of mathematics teachers in the post-primary teachers' colleges of Benue, Kaduna, and Sokoto States of Nigeria.

Significant positive correlations were found between the teachers' attitudes toward accepting curriculum change and both their previous participation in curriculum development and their knowledge of the new programme. After the first administration of the instrument (pre-test), an experimental group of teachers attended a special workshop (one was organized in each of the three states), designed to familiarize them with the new curriculum and solicit their suggestions for its further development. The teachers who did not attend the workshop formed the control group. Shortly after the workshop, the instrument was again administered to all teachers (post-test). The experimental group showed significant gains in their scores on attitude toward curriculum change and knowledge of the new programme. The control group showed no significant change in knowledge and significant decline in attitude over the same period. A third administration of the instrument, with no further intervention, showed slight, but non-significant, declines in the attitude, knowledge, and participation scores of the experimental group.

Further statistical analysis considered various personal factors - qualifications, teaching experience, and nationality of the respondents, but found few significant interrelationships with the main variables of the study.

The experience of the researcher in organizing the experimental workshops yielded practical suggestions for future efforts in familiarizing teachers with new curricula, especially through the use of workshops. Also the current status of the official implementation campaign for the new syllabuses was observed. It was noted that many teachers were not aware of the new programme.

Conclusions and recommendations noted the importance of, and need for more, early teacher participation in mathematics curriculum development, more use of familiarization workshops, establishment of more teacher centres, and generally, better communication between classroom teachers and mathematics curriculum developers.

TABLE OF CONTENTS

Declaration	i
Approval Sheet	ii
Copyright	iii
Acknowledgements	iv
Abstract	vii
Table of Contents	xi
List of Tables, Figure	xx
Acronyms	xxi
Dedication	xxiii
In Memory	xxiv

Chapter 1 INTRODUCTION 1

1.1 Background 1

1.1.1 Curriculum Implementation, Difficult but Necessary 1

1.1.2 Teacher Variation in Curriculum Presentation 2

1.1.3 Advantages of Early Teacher Participation in Curriculum Development 4

1.1.4 Problems of Early Teacher Participation in Curriculum Development 6

1.2 Statement of the Problem 7

1.2.1 Description of the Problem Area 7

1.2.2 Objectives 8

1.2.3 Sub-problems 9

1.3 Hypotheses 10

1.3.1 Explanation 10

1.3.2 Null-Hypotheses 10

1.4 Justification 11

1.4.1 Reasons for the Study 11

1.4.2 Recent Developments in Mathematics Curricula 12

1.4.3 Academic Research 14

1.4.4 Studies in West Africa 14

1.4.5 Practical Applications and Current Policies 17

1.5 Definition of Terms 18
1.5.1 Definitions 18
1.5.2 Curriculum 19
1.5.3 Teacher 21
1.5.4 Implementation 22
1.5.5 Familiarization 24
1.5.6 Participation 25
1.5.7 Attitude 26
1.6 Scope of the Study 28
1.6.1 Focus 28
1.6.2 Assumptions 28
1.6.3 Delimitations 29
1.6.4 Limitations 29
1.7 Organization and Summary of the Study 31
1.7.1 Chapter Organization 31
1.7.2 Summary 32
Chapter 2 SURVEY OF LITERATURE 34
2.1 Outline 34
2.2 Mathematics Curriculum Development 35
2.2.1 Mathematics Curricula Before 1900 35
2.2.2 Mathematics Curricula: 1900-1950 36
2.2.3 The Start of "Modern Mathematics" 40
2.2.4 SMSG and Later "Modern Mathematics" in the United States 44

2.2.5 "Modern Mathematics" in Britain 49

2.2.6 "Modern Mathematics" around the World 53

2.2.7 Mathematics in Africa before 1960 60

2.2.8 African Mathematics Programme (Entebbe Mathematics) 62

2.2.9 JSP and Other "Modern Mathematics" Programmes in West Africa 66

2.2.10 Developments in Nigeria Leading to to the 1979 Syllabuses 70

2.2.11 Teacher Education Mathematics Curriculum (1979) 80

2.2.12 Section Summary - Mathematics Curriculum Development 84

2.3 Curriculum Implementation 86

2.3.1 Growth of Curriculum Study 86

2.3.2 Diffusion of Educational Innovations 89

2.3.3 Models of Educational Implementation 97

2.3.4 Case Studies of Implementing Curriculum Change 112

2.3.5 The Role of Teachers in Curriculum Implementation 123

2.3.6 Studies of Curriculum Implementation in Africa 128

2.3.7 Studies from Nigeria 135

2.3.8 Section Summary - Curriculum Implementation 143

BEST COPY AVAILABLE

2.4 Other Literature 146
  2.4.1 Sources of Information 146
  2.4.2 Research Design, Methodology, and Data 147
  2.4.3 Theories of Attitude Change 149
  2.4.4 Analysis and Conclusions 154

Chapter 3 PROCEDURE 157
3.1 Introduction 157
3.2 Research Design 158
  3.2.1 Basic Design 158
  3.2.2 Measurements 159
  3.2.3 Treatment 161
3.3 Case Study 162
  3.3.1 Description of the Case 162
  3.3.2 Description of the Location of the Study 165
  3.3.3 Experimental Groups 172
3.4 The Instrument 176
  3.4.1 Description 176
  3.4.2 Sources of Item Contents 180
  3.4.3 Development to the Final Form 184
  3.4.4 Validity and Reliability 187
  3.4.5 Administration 189

3.5 The Workshops 191

  3.5.1 Rationale 191

  3.5.2 Arrangements 191

  3.5.3 Materials 199

  3.5.4 The Programme 201

3.6 Data Analysis 210

Chapter 4 ANALYSIS OF DATA 213

4.1 Introduction 213

4.2 Numbers of Questionnaires and Respondents 214

4.3 Scoring 216

  4.3.1 Participation 216

  4.3.2 Knowledge 218

  4.3.3 Attitude 219

4.4 Correlation Results 221

  4.4.1 Technique 221

  4.4.2 Hypothesis 1 222

  4.4.3 Hypothesis 2 223

  4.4.4 State Results 224

  4.4.5 Participation vs. Knowledge 224

  4.4.6 Multiple and Partial Correlations; and Regression 225

4.5 Pre-Test - Post-Test Results 226
4.5.1 Technique 226
4.5.2 Hypothesis 3 227
4.5.3 Hypothesis 4 228
4.5.4 Change in Participation Scores 230
4.5.5 "Retention" Effects 230
4.6 Personal Factors 232
4.6.1 Scoring and Mean Values 232
4.6.2 Correlations 234
4.6.3 Analysis by Nationality 237
4.7 Opinions 240
4.8 Summary of Data Analysis 242

Chapter 5 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 245
5.1 Summary of the Project 245
5.1.1 Areas of Research 245
5.1.2 Historical Research 246
5.1.3 Theoretical Research 247
5.1.4 Statistical Research 248
5.1.5 Experiential Research 250
5.2 The Findings 252
5.2.1 Types of Findings 252
5.2.2 Historical Findings 253

BEST COPY AVAILABLE

5.2.3 Theoretical Findings 258

5.2.4 Statistical Findings 263

5.2.5 Experiential Findings 268

5.3 Methodological Problems 272

5.3.1 Non-Experimental Difficulties 272

5.3.2 Problems in Data Collection 274

5.3.3 Problems of Statistical Analysis 277

5.4 Conclusions 280

5.4.1 Reference to the Findings 280

5.4.2 Early Participation of Teachers in Curriculum Development 280

5.4.3 Familiarization Workshops 282

5.4.4 Communication 283

5.4.5 Teacher Centres 284

5.5 Recommendations 285

5.5.1 Source 285

5.5.2 Methodological Recommendations 285

5.5.3 Recommendations from the Conclusions 286

5.5.4 Recommendations on Practical Details 288

5.5.5 Recommendations for Further Research 289

Bibliography 291

Appendix A: Letter to Ministries of Education 322

Appendix B: List of Teachers' Colleges 326

Appendix C: Pilot Instrument 329

Appendix D: The Instrument 337

Appendix E: Evaluation of "Practice" Workshop 346

Appendix F: Workshop Programme 349

Appendix G: Statistical Techniques 353

BEST COPY AVAILABLE

LIST OF TABLES

Number	Title	Page
2.1	Comparison of Terminologies of Stages of Implementation	120
3.1	Z- and F-ratio Values to Compare Means and Variances of Experimental and Control Groups in Six Variables	175
4.1	Categories of Returned Questionnaires	215
4.2	Categories of Individual Respondents	215
4.3	Mean Values of the Participation Score (P), by State	217
4.4	Mean Values of the Knowledge Score (K), by State	219
4.5	Mean Values of the Attitude Score (A), by State	220
4.6	Correlations r_{AP} and r_{AK}, by State	224
4.7	Correlations between P and K	225
4.8	Score Differences between Post-Test and Third Test	231
4.9	Correlation Matrix of A, P, K, E, M, and T	235
4.10	Average Scores on the Six Variables, by Nationality Group	238

FIGURE

3.1	Nigeria	167

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ACRONYMS

A	Attitude (variable)
AMP	African Mathematics Programme
ATC	Advanced Teachers' College
CDITC	Curriculum Development and Inservice Training Centre
CEEB	College Entrance Examination Board
CESAC	Comparative Education Study and Adaptation Centre
CLER	Configurations, Linkages, Environment, Resources
DAI	Dissertation Abstracts International
DEI	Developmental Education Institute
DESS	Division of Extension and Support Services
E	Education training (variable)
EARMP	East African Regional Mathematics Project
EDC	Educational Development Corporation
ERC	Educational Resource Centre
ESI	Educational Services, Incorporated
IOWO	Instituut Ontwikkeling Wiskunde Onderwijs
IREM	Instituts de Recherche sur l'Enseignement des Mathématiques
JSP	Joint Schools Project
K	Knowledge (variable)
LMMP	Lagos Modern Mathematics Project
M	Mathematics training (variable)
MAN	Mathematical Association of Nigeria
MMCP	Mathematics for the Majority Continuation Project

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MTT	Mobile Teacher Trainer
NACOME	National Advisory Committee on Mathematics Education
NCTM	National Council of Teachers of Mathematics
NERC	Nigeria Educational Research Council
NTI	National Teacher Institute
NYSC	National Youth Service Corps
P	Participation (variable)
PEIP	Primary Education Improvement Project
PSSC	Physical Science Study Committee
RD & D	Research, Development, and Diffusion
SCDC	Science Curriculum Development Centre
SEP	Science Education Project
SEPA	Science Education Programme in Africa
SMSG	School Mathematics Study Group
SMP	School Mathematics Project
T	Teaching experience (variable)
UICSM	University of Illinois Committee on School Mathematics
UMMaP	University of Maryland Mathematics Project
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNICEF	United Nations Children's Fund
UPE	Universal Primary Education
WAEC	West African Examinations Council
WARMP	West African Regional Mathematics Project
WASC	West African School Certificate

(Note: Statistical notation is discussed in Appendix G)

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Dedicated to

My parents, my wife, and my children

In Memory of

Dr. Richard Forshaw
Shahon Zazzau
C.B.T.
1915 - 1983

Chapter 1

INTRODUCTION

1.1 Background

1.1.1 Curriculum Implementation: Necessary, but Difficult

In the past twenty-five years educators in many countries have been designing new curricula in mathematics and many other subject areas. They have been attempting to modernize courses; to incorporate new developments from research in education, psychology, and the content fields; and to make the subject matter and teaching approaches more relevant to the needs of the students and of society. Accompanying any new work in curriculum design, there must be ways of bringing the new programme into the schools. The design work will be futile without successful implementation. Hence the factors involved in bringing the changes to the schools have become an important concern of curriculum theory and practice. (Some of the work in mathematics curriculum development is discussed in Section 2.2 below; Section 2.3 covers some of the problems and ideas on implementation.)

In Nigeria and many other developing countries, education is expanding rapidly and new programmes have become key ingredients in the new directions of education. Nigeria's National Policy on Education (1977, 1981) was specially prepared to offer guidance in shaping educational programmes to meet national goals. However, the difficulties of bringing new programmes to the classroom are perhaps even greater than elsewhere - especially considering budget restrictions, the perpetual contest between quantity and quality, and the special needs for teacher education and in-service training. Several writers, notably Hawes (1979) (Section 2.3.6.2), highlight some of these difficulties. It often happens that useful curriculum innovations fail primarily because of these difficulties of implementation, especially the insufficient efforts to involve teachers in the developmental process or even to familiarize them with the changes. Vogeli (1976) makes an especially strong case for this problem in much of "modern mathematics"; more locally, Potts (1967) and Ohuche (1978) refer to such difficulties in the Entebbe Mathematics and other programmes.

1.1.2 Teacher Variation in Curriculum Presentation

The wide variations in teacher ability, experience, professionalism, and autonomy have forced curriculum developers to realize that teachers cannot be treated as teaching machines, ready to replicate for their classes whatever curriculum is fed into them.

Several of the big curriculum projects of the 1960s tried to make their programmes "teacher-proof" but they soon learned that "each teacher filters the materials through his own perceptions and to say that a student has been through the.... curriculum probably does not give as much specific information as the curriculum innovators might have hoped." (Gallagher, 1967, p.17)

Good teachers - highly qualified, creative, and thoughtful - have their own ideas of what should be taught and where emphasis should be placed. They may not want to follow a curriculum which they consider inferior to their own ideas. (Shipman (1974) pp. 22, 90; MacDonald and Walker (1976) pp. 49, 50). They may resent the snub of the curriculum developers not having called on them for suggestions, and in fact the lack of their advice may have even weakened the programme's design.

The other kind of deviation from the given curriculum comes from the weaker, and often unqualified teachers. Unfortunately, because of the seriousness of teacher shortages, especially in developing countries and particularly in mathematics and science subjects, this problem is much more common than the former. Teachers lacking skill, or experience, or even understanding of the material, can unintentionally twist the objectives, contents, and approaches

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of new curricula to result in a serious distortion (Davis, 1971). They may teach new topics by rote, without fully comprehending them, using the discarded methods of older curricula. They may ignore the new, unfamiliar material altogether, depriving their students of the chance even to see the new offerings. Often, as Fakuade (1980) pointed out in the case of "modern mathematics" in Nigeria, the public complaints about new curricula really reflect concern over poor instruction rather than inappropriate material.

1.1.3 Advantages of Early Teacher Participation in Curriculum Development

Involving classroom teachers in the curriculum development process at an early stage would help curriculum development in several ways:

First, the curriculum would benefit from the teachers' creative ideas on content and their realistic knowledge of the classroom situation. It is likely that local classroom teachers will be more familiar with the life and culture of the students and hence these teachers could help make the curriculum more relevant to local needs and the students' background. Several programmes recruited teachers as writers especially for this reason (Watson, 1976, p. 90; Shipman, 1974, p. 22).

Secondly, teachers would become more knowledgeable of of the objectives of the new programme, and would have a chance to learn the new content themselves and to try out the new instructional practices. Peltier (1967, p. 215), reporting an earlier effort at teacher participation in curriculum design, stated that, "Teacher participation resulted in a teaching staff increasingly alert to its problems. The programme of curriculum revision had stimulated and motivated professional study and had been most effective in creating the desire for the assistance of constructive supervision".

In addition, teachers would now have a greater stake in the success of the programme and would have greater motivation in implementing the new material. Having made a contribution - in some way - to the development of a programme should give the teacher a feeling that it is his own, and not something that outsiders have forced upon him. Taylor (1981) referred to this feeling as "ownership in change" and referred to Hersey and Blanchard's (1977) survey of employees, which pointed to their desire to be involved and knowledgeable of coming changes. Being a part of the change process greatly increased their support of the change.

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1.1.4 Problems of Early Teacher Participation in Curriculum Development

Unfortunately, the ideal situation of early participation of classroom teachers in curriculum development is often difficult to arrange when a realistic view is taken of the logistics of the developmental effort. An argument may even be made that such early involvement is undesirable. A brief listing of some of the problems follows:

(1) If teachers are to be brought together for a curriculum conference there are many organizational difficulties: selection of a reasonable sample of teachers, arrangements and costs of such a conference, and the desire to keep teachers in their classrooms where their teaching services are desperately needed.

(2) If a conference seems impossible, it may be suggested that teachers on-the-job be asked to contribute recommendations by filling in questionnaires or by making oral comments to visiting inspectors or curriculum developers. However, this may prove to be a fruitless venture as the teachers' suggestions would tend to be unorganized and disconnected unless they can have a chance for free interchange and discussion of ideas. Also, completing questionnaires tends to have rather low priority in the time budget of overworked teachers.

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(3) Even without such consideration of the organizational problems, it might be argued that teacher input into the design of a programme is not very valuable anyway: Teachers may tend to be conservative and only support what has "worked" in the past; teachers' views of the curriculum may be too parochial - limited to the class-level where they teach or the local situation of their own school, rather than the broader viewpoint embracing general curriculum objectives, the overall content plan, and the national application often intended for big curriculum projects; and, especially when there is a shortage of qualified teachers, the person teaching mathematics in the school may lack the sophisticated understanding of the mathematics content (or the psychology of learning or other advanced academic bases of educational theory) to be able to make meaningful contributions.

1.2 Statement of the Problem

1.2.1 Description of the Problem Area

Although the validity of the arguments against teacher participation in curriculum design (Section 1.1.4) may be debatable, their existence does mean that the case in favour of such early participation must be demonstrated in order to justify the expense of time and money required for arranging this involvement.

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Therefore, the purpose of this study is to examine the effect of early teacher participation and familiarization with a new mathematics curriculum in terms of teacher attitude toward, and understanding of the new curriculum.

The study includes a review of past efforts in mathematics curriculum design and of other studies of curriculum implementation and it focusses particularly on the present curriculum development in mathematics in Nigeria and its implementation in the northern states. The programme implementation actually under investigation is that of the Teacher Education Mathematics Curriculum (Federal Ministry of Education, 1979).

1.2.2 Objectives

The main objectives are:

(1) To measure the correlations **of** (a) teachers' early participation in the curriculum development; and (b) their knowledge of the content and philosophy of the new curriculum; with (c) their attitude toward the introduction of the new curriculum; and

(2) to determine the effect of attendance at a special workshop on the measures of (b) and (c) in (1), when the workshop has been especially designed to both familiarize

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teachers with recent developments in the mathematics curriculum and to involve the teachers by asking for their suggestions and assistance in further development of the curriculum.

1.2.3 Sub-problems

Some additional areas of investigation, related to the main study, are:

(1) a study of previous projects of mathematics curriculum development and implementation, with particular interest in the participation of teachers in the projects (a part of the survey of literature);

(2) a review of findings from academic studies of the curriculum implementation process, again with special focus on the role of teachers (also in the survey of literature);

(3) an analysis of the practical problems of arranging and organizing the workshops mentioned in Objective (2) above; and

(4) further statistical study to investigate relationships between teachers' qualifications and other personal factors and their knowledge of new curricula, participation in curriculum development, and especially, attitude toward accepting new curricula.

1.3 Hypotheses

1.3.1 Explanation

The specific hypotheses to be tested are stated below in the null-hypothesis form. Further explanation of the testing of these hypotheses and the methods used to study the problem are included in Chapters 3 and 4. In particular, it should be noted that the phrases "level of participation", "level of knowledge", and "attitude" refer to the three major variables measured by the research instrument, with a score for each variable for each respondent. These measures are defined and discussed in Sections 1.5.6 and 1.5.7 of the present chapter and Sections 3.2.2 and 3.4.1 in Chapter 3. The results of the testing of the four hypotheses are reported in Sections 4.4.2, 4.4.3, 4.5.2, and 4.5.3, respectively, of Chapter 4.

1.3.2 Null-Hypotheses

Hypothesis 1 There is no significant correlation between the teachers' levels of participation in the curriculum development process and their favourable attitudes toward the introduction of the resulting curriculum into the schools.

Hypothesis 2 There is no significant correlation between the teachers' levels of knowledge about the goals and content of the new curriculum and their favourable attitudes toward the introduction of the curriculum into the schools.

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Hypothesis 3 There is no significant change in the teachers' knowledge of the goals and content of the new curriculum after attendance at a three-day curriculum familiarization workshop.

Hypothesis 4 There is no significant change in the teachers' attitudes toward the introduction of new curriculum into the schools after attendance at a three-day curriculum familiarization workshop.

1.4 Justification

1.4.1 Reasons for the Study

The original justification for this study has already been mentioned in Sections 1.1 and 1.2: the necessity to check the intuitive conjecture that greater teacher participation in mathematics curriculum development will aid the implementation of the resulting curriculum by making the teachers more willing to accept it. However, this rather narrow issue must be considered in a larger pattern of problems, developments, and gaps in research literature, all of which call for more studies in this field. Some of the needs to which this project attempts to respond are discussed in the following four sub-sections. They are organized under Recent Developments in Mathematics Curricula, Academic Research, Studies in West Africa, and Practical Application of Current Policy. However, this is mostly for convenience, as the issues actually overlap and cannot be neatly classified.

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1.4.2 Recent Developments in Mathematics Curricula

Much effort has gone into the development of new mathematics curricula all over the world in the past quarter-century. Some of the resulting programmes appeared to be radical departures from older curricula - so much so that the changes were called a "revolution" in mathematics (National Council of Teachers of Mathematics, 1961) (See Sections 2.2.3 to 2.2.6). The wave of change was felt also in Africa - specifically in Nigeria - with a series of new mathematics programmes beginning with the Entebbe Mathematics Series (Section 2.2.8) in the early 1960s, and continuing through the debate in the 1970s over the merits and demerits of the so-called "traditional" and "modern" mathematics (Section 2.2.10). The 1980s have brought efforts to prepare textbooks for the latest syllabuses (Federal Ministry of Education, 1979) (Sections 2.2.10 and 2.2.11). The work of curriculum development has involved university mathematicians and mathematical associations (such as the Mathematical Association of Nigeria), Ministries of Education and their inspectorates, foreign advisors and funding agencies, commercial publishers and writers, the West African Examinations Council, and, occasionally, classroom teachers of mathematics.

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However, after so many years of labour by so many people and agencies all around the world, it is still debatable whether teachers are really teaching mathematics any better or - more significantly - if students are really learning more mathematics or learning it any better. Doubts about the lasting effects of "modern mathematics" have been expressed in many studies: the report of the Conference Board of the Mathematical Sciences (1975), Freudenthal (1978a), and Howson, Keitel, and Kilpatrick (1981) are among the most comprehensive; recent local reports are Ohuche (1978) and Fakuade (1980). These and others argue that the new curricula were not successfully implemented. On the contrary, the controversy over the programmes, the difficulties of the teachers, and the continuing poor results in examinations all are **cited** by these sources as evidence of incomplete or faulty implementation.

If so much effort has gone into meeting demands for stronger mathematical background for our future citizens, and yet the programmes have not succeeded, these expenses for curriculum development must be matched by greater work at improving the implementation process. Several of the same sources just mentioned as well as others (e.g., Vogeli (1976), Price and Gawronski (1981)); point to this need in calling for more study of curriculum implementation, especially in mathematics.

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1.4.3 Academic Research

The study of curriculum implementation, as is described in Section 2.3.2, arose largely in an attempt to investigate problems met by the curriculum developers of the 1960s. Even as early as 1964, Miles (1964a) called for more study of this area. Sections 2.3.3 to 2.3.5 report on some of the response to such calls. A variety of models were developed, often based on more general issues of change and innovation in organizations and in society. Case studies were made of a variety of curriculum changes and the diffusion of these new programmes into classroom use. But the process is a very complicated one, and by the mid-1970s, Dalin (1973) (Section 2.3.3.4) argued that no single model could neatly summarize such a complex mixture of forces, demands, and restraints. Fullan and Pomfret (1975) (Section 2.3.4.4) reviewed many studies, and while praising the good beginnings, they pointed to many weaknesses and gaps in the understanding of the field. They said that much more work must be done.

1.4.4 Studies in West Africa

The paucity of research studies in this field is even greater in West Africa. Although there has been much activity in mathematics curriculum development in West Africa, there have been few historical or evaluative research studies made

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of these efforts. Some reports are mentioned in Chapter 2 (Sections 2.2.8 to 2.2.10), notably the articles of G. Williams (1974) and Ohuche (1978), but many are little more than reports, often written by the director of a project to explain what the project was doing or what the project team hoped to accomplish. Part of this lack of objective academic studies is simply a reflection of the shortage of mathematics educators: nearly everyone who might have made such a study was recruited to assist with one project or another. Another reason also is linked to the manpower shortage: there have been very few doctoral studies in mathematics education in West African universities. A recent bibliography of mathematics education in Nigeria (Adeniran et al, 1983) lists only seven doctoral theses (though this may have omitted a few).

Even among the few studies that have been made of West African mathematics curricula, few discuss implementation (See Sections 2.3.6 and 2.3.7). The report of G.Williams (1974) (Section 2.3.7.4) does offer a good description of the implementation of one mathematics project, including aspects of teacher participation and training. (Also, Quinlan (1972) (Section 2.3.6.3) discusses teacher involvement in English curriculum change in East Africa, and B. Young (1975) (Section 2.3.7.3) studies problems of implementation of a primary science curriculum in northern Nigeria). However, no empirical studies were found where teacher involvement is linked to the ease of implementation.

Most studies have put emphasis on the development aspects of the curriculum, such as selecting appropriate content or devising suitable presentation methods. These concerns certainly are important; without discussions such as these, there might have been no improvement, nor even any change in the mathematics curricula. Content and sequence of learning experiences form the core of curriculum study. But, as was stressed above in Section 1.4.2, the results of such curriculum work will not reach the student without adequate implementation.

The additional restraints in developing countries - rapid expansion of education, shortage of resources, etc. (mentioned in Section 1.1.1 above and discussed in Hawes (1979)) - require special study of curriculum implementation problems in these regions. Also, such study might bring out cultural differences in views toward curriculum change, and resulting implications for implementation strategies. However, little has been done in this area.

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1.4.5 Practical Applications and Current Policies

Several practical considerations and the immediate situation of mathematics education in Nigeria in the early 1980s make this study particularly relevant and timely. The Teacher Education Mathematics Curriculum (Federal Ministry of Education, 1979) is just reaching the stage of final development and implementation. Work is getting underway to prepare textbooks based on the syllabus and efforts to familiarize the teachers with the programme have begun.

The study is a participant-observation study in the sense that it not only observes and theorizes about the curriculum implementation process, but through the organization of the experimental workshops (described in Section 3.5), the project also attempts to assist in the process. The timing is such that the observation comes at the ideal time to record teacher responses at the beginning of the familiarization and implementation process. Perhaps this might serve as a baseline for further study several years hence.

The participation of the researcher in the implementation offers a chance not only to aid the process, but also to record the real difficulties and details of arrangements that are involved. Much of Section 3.5 is devoted to this report, given in considerable detail, partially since it is the experimental treatment of the research, but also as a guide

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to others who are put into a position of organizing workshops for curriculum development and implementation. Of course, every such situation has its own demands, but it is hoped that the experience in one case may provide some assistance in others.

It is hoped that the results and recommendations of this work can (1) strengthen the academic study of curriculum implementation in mathematics; (2) help fill the relative lack of curriculum studies in West Africa and Nigeria in particular; (3) consider especially the role of teachers in the development and implementation of curricula; and (4) provide practical assistance and advice to current efforts in curriculum development and implementation and in-service teacher education.

1.5 Definition of Terms

1.5.1 Definitions

A few terms will be given special meanings for the purposes of this study, slightly different or more sharply focussed then the general usage of the terms in other writings on education. Before proceeding any further, it is necessary to discuss these special shades of meaning.

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1 5.2 Curriculum

The word "curriculum" is probably defined more often and agreed upon less often than any other term in education, with the possible exceptions of "learning" and "education" itself. The range of definitions runs from a narrow "List of subjects" to a very broad "everything that happens to a learner". Hosford (1973) and Tanner and Tanner (1975) both offer extensive discussion and comparison of various definitions, including those based on the disciplines and subject areas; those of the child's experiences of learning - the planned vs. the unintended outcomes; the teacher's own designs for individual classes and the big projects for national implementation.

The term as used in this study is quite specific. To discuss acceptance of curricula by teachers implies a particular programme to be accepted; one which has been developed on a fairly large scale and is intended for use by many teachers in many classrooms. This is the meaning of curriculum implied throughout this study, unless otherwise stated. This kind of curriculum may be represented by a new syllabus approved by educational authorities, a new textbook or series of textbooks, perhaps including other associated teaching materials, or the large, highly organized "curriculum project" (Shipman, 1974) that became popular in many areas in the 1960s and 1970s.

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The specific curriculum referred to in the experimental part of this study is the programme of syllabus development for mathematics in the teachers' colleges in Nigeria (Federal Ministry of Education, 1979), coordinated by the Nigeria Educational Research Council as a part of the effort of the Federal Ministry of Education to develop new curricula in mathematics for all levels of schools; and also the resulting preparation of new textbooks and teaching materials, by public agencies as well as commercial publishers, to meet the requirements of this new syllabus.

It should be noted that, for convenience throughout this study, the phrase "modern mathematics" (in quotation marks) will refer generally to any and all of the many revisions made in school mathematics between the 1950s and the early 1970s (but usually *not* the most recent programmes since the mid-1970s) (See Sections 2.2.3 to 2.2.9 for a brief account of the history of "modern mathematics".). Although, as is discussed in Section 2.2.4.4, this term sometimes caused confusion because of the variety of programmes which were all labelled "modern mathematics" it *is* the term generally used, and, *ex post facto*, it is a useful way to refer to the total effort at mathematics curriculum change in that period.

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1.5.3 Teacher

Since this study refers to mathematics curricula, the word "teacher" will usually mean a teacher of mathematics, unless the context implies otherwise. Due to the shortage of qualified mathematics teachers in many parts of Nigeria, many mathematics classes may not have a teacher with particular training in the teaching of mathematics. But whatever his qualifications may be, a person teaching mathematics necessarily interacts with the mathematics curriculum. In fact, in terms of accepting a new curriculum, it might be argued that the response of the unqualified teacher is more significant to the success of the programme as he will probably need more familiarization and training to handle the new material (See Watson, 1976, p. 77). Thus, "teacher" will refer to anyone who teaches mathematics, regardless of his qualifications, previous training, or past experience. Since many expatriates are teaching mathematics in Nigeria, the term will also include them, unless the context specifically excludes them.

Most of the references to teachers will mean post-primary mathematics teachers, in secondary schools or in teachers' colleges. However, the experimental part of the study is restricted to the mathematics teachers in the

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teachers' colleges. See also Section 3.3.1.1 for more description of these teachers, and Section 4.6 for a summary of the personal data collected from the respondents.

1.5.4 Implementation

Many interrelated terms have been used in the research literature for the various steps of introducing and gaining acceptance of educational innovations. Further discussion is in Sections 2.3.2.2 and 2.3.4.4. Here, "implementation" is described in a brief summary of the steps of the process. This outline is based on Hoyle (1972) as reported by Bolam in his chapter in Shipman (1974, p. 159-168).

Research and development stages provide knowledge for the innovation and produce the new programme. The next stage is *diffusion*, or the spread of the innovation out from its creators to potential users. Diffusion can be considered in two sub-steps: first, *dissemination*, when the would-be adopters are informed about the proposed programme; and then, *demonstration*, which is an attempt to win support by showing the value and effectiveness of the innovation. True *implementation* would follow as schools actually begin to use the new programme. Finally, the job is completed in *institutionalization*, making sure the new plan stays and is brought fully into regular, relatively permanent use.

Often all of the steps after development are labelled "implementation", and, in fact, one of the questions of this study is to investigate the effect of teacher participation in the research and development stages on the eventual success of the programme, thus even implying that implementation may overlap with research and development. This indicates the difficulty of pinning down a precise definition of "implementation".

Here "implementation" will usually be restricted to the step described above - the start of actual use of a new curriculum - except when the phrase "implementation process" or the context implies the more general meaning. This attempt at the more specific meaning, of course does not imply any lack of interrelationship or influence among the stages of the process. Katz, Leven, and Hamilton (1963, p. 240) try to show not only the interrelated steps but also some of the factors involved when define the adoption of educational innovations as the "(1) acceptance, (2) over time, (3) of some specific item - an idea or practice, (4) by individuals, groups, or other adopting units linked to (5) specific channels of communication, (6) to a social structure, and (7) to a given system of values or culture".

1.5.5 Familiarization

"Familiarization" refers mainly to the stage of "diffusion" in the implementation process described above. Literally, teachers are made familiar with the new curriculum - its existence, its aims and goals, its content, its teaching materials, its methodology. Familiarization may happen through workshops and seminars, written announcements and explanations, individual briefings, or even newspaper reports. Probably familiarization fits the first substage of diffusion - that of dissemination - most easily, as it is largely a matter of spreading information to the teachers about the new programme. However, it is certainly a good opportunity for the demonstration substage also; not only will teachers be told of the programme, but also it is hoped they can be "won over" to accepting and supporting it by coming to understand its value and usefulness.

It should be noted that, although this study is concerned with familiarization of teachers, there are many others who need to become familiar with a new programme for its introduction to proceed smoothly and successfully.

Some of these might be examination authorities, various officials in the Ministries of Education, other teachers (such as science teachers and teachers in the levels below and above the level where the new programme is to be used), potential future employers of the students, parents, and the general public. Of course, the students themselves should also be made aware of the coming changes in their course of study.

1.5.6 Participation

"Participation" will specifically refer to a classroom mathematics teacher (or other teacher, according to context) working in some way to help develop a new curriculum, by contributing suggestions, serving on a planning committee, preparing a syllabus, designing materials, writing textbooks, helping to inform others of the work, or, as a minimum level of participation, at least being aware, at an early stage of the project, of what it is doing. Participation is one of the factors measured in the experimental part of this study and is discussed further in the description of the instrument and the methods of analysis in Chapter 3 (Sections 3.2.2 and 3.4.1.2), and in the actual analysis of the data in Chapter 4 (Section 4.3.1 and others). Some examples of participation can also be seen in Section B of the instrument (Appendix D). Some references in the literature are given in Chapter 2 (Sections 2.3.4.4, 2.3.5, and others). Occasionally, the term "involvement" is used as a rough synonym for "participation", with the connotation of being a part of the development process.

1.5.7 Attitude

Attitude is another factor measured in the experimental part of this study and is discussed further in Sections 2.4.3, 3.2.2, 3.4.1.1, 4.3.3, and others. However, a very specific attitude is under consideration. "Attitude" here refers to a teacher's feelings about starting to use a new mathematics curriculum in his class. It does not necessarily mean his attitude toward mathematics, toward teaching, or even toward the curriculum development process - but only how he feels about actually making the effort to begin to use a new mathematics programme in his own classes. Note, for instance, that a creative, highly skilled teacher with a favourable attitude toward the teaching of mathematics may prefer to design his own plans. Another teacher may strongly agree with the need for curriculum development, but may feel frustrated about not having had an opportunity to contribute to designing a new programme, and hence may have a negative attitude toward a programme which he feels has been imposed on him by outsiders. Another dedicated teacher may have conservative views about mathematics education and hence question any major departure from the old curriculum. However favourable the attitudes of these teachers may be toward teaching and mathematics, they all may become obstacles to successful implementation of a new curriculum, and since that is the theme of this study, they all would be recorded as having negative attitudes.

Of course, more often it would be expected that attitude toward teaching mathematics would correlate with attitude toward accepting and using a new curriculum. An unenthusiastic or unqualified teacher may object to having to reorganize his lesson notes or learn new content, while a dedicated, competent teacher may have even helped to develop the new curriculum and might start to use it even before it is formally launched.

This specific kind of attitude is demonstrated in the items of Section A of the instrument (Appendix D).

The six key terms discussed in this section can all be used in one sentence to restate the central question of this study: Will the participation and familiarization of teachers in the development of a new curriculum in mathematics give them a more favourable attitude toward its implementation?

1.6 Scope of the Study

1.6.1 Focus

When this study was first considered, its scope was very broad - general problems of implementing new mathematics curricula in the English-speaking countries of West Africa. This comprehensive viewpoint remains a background theme for the present study and is especially reflected in the range of materials covered in the survey of literature in Chapter 2. However, such breadth is almost impossible to handle within the confines of dissertation research - or any individual research project. Hence, the more specific problem stated earlier (Section 1.2) resulted from an effort to focus the study much more sharply. To clarify the scope of this study it is necessary to list basic assumptions, delimitations, and limitations which must be noted in any consideration of the findings.

1.6.2 Assumptions

The following assumptions were made in this study:

(1) The instrument and procedures used were suitable for the collection of accurate and valid data about the participation of teachers in curriculum development, the knowledge teachers have about new curricula, and the attitude of teachers toward accepting new curricula for classroom use; and about the interrelationships between these data.

(2) The responding teachers adequately represent mathematics teachers in teachers' colleges in the three states of the study (Benue, Kaduna, and Sokoto States).

Discussion of the bases for these assumptions are given in Chapter 3 (Section 3.4.4 and 3.4.5; and 3.3.3 respectively).

1.6.3 Delimitations

The following delimitations apply:

(1) The study considers only mathematics teachers in teachers' colleges in Benue, Kaduna, and Sokoto States.

(2) The study reflects the situation in late 1981 and early 1982 (the time of the data collection) in terms of curricula currently being introduced, the current qualifications, nationalities, and attitudes of teachers, and the current school administrative arrangements.

(3) The principal method of collection of data is restricted to the research instrument, supplemented by informal interviews conducted by the researcher.

1.6.4 Limitations

The following are limitations on this study:

(1) The accuracy of the results depends on the ability of the researcher to collect the data and to interpret it objectively in drawing conclusions.

(2) The results apply directly only to teachers of mathematics in teachers' colleges in Benue, Kaduna, and Sokoto States, and any generalizations attempted for other subject areas, other types of schools, or other geographical areas must be taken only as unsupported extrapolations of available data. (However, as described in Section 3.3.2.6 and stated in Section 5.3.3.4 there is some justification for geographical generalization to other areas.)

(3) Part of the instrument is an attitude survey, which depends on honest self-report on the part of the respondents. Efforts were made in the instructions to respondents and the protocols of administration to encourage honesty and frankness, as described in Sections 3.4.1 and 3.4.5.

(4) The small number of teachers of mathematics and the limited opportunity of the researcher to make direct contact with teachers in a wider area forced the numbers used in the statistical analysis to be lower than would be desired to obtain more reliable results. However, as discussed in Section 5.3.2.4, the numbers were adequate for the study.

1.7 Organization and Summary of the Study

1.7.1 Chapter Organization

This study is organized into five chapters: Chapter 1 is the Introduction and includes background and justification of the study, a formal statement of the problem and hypotheses, and a discussion of the special terminology and the scope of the study.

Chapter 2 is the Survey of Literature. It includes (1) an overview of worldwide mathematics curriculum development with a focus on mathematics curriculum development and implementation in the context of West Africa and specifically Nigeria; (2) a review of theoretical models and case studies of the process of curriculum implementation and the role of teachers in the process; and (3) a summary of other literature helpful in the research procedures. These reviews represent the background and point of departure of the present study.

Chapter 3 is Procedure, with explanations of how the research was designed and carried out, and the statistical background to the experimental part of the study. Since the organization of the series of workshops was an important part of the experiment, this aspect is discussed in detail.

Chapter 4 is the Analysis of the Data resulting from statistical interpretation of the data collected to test the hypotheses and to derive further results.

Chapter 5, Summary, Conclusions, and Recommendations summarizes the study, reports the principal findings and conclusions, and makes policy suggestions for improving the implementation process as well as comments on further necessary research in the area.

1.7.2 Summary

This study is centred on the participation of teachers in mathematics curriculum development and especially with familiarizing mathematics teachers with a new curriculum as a factor in improving their attitude toward accepting curriculum change.

The study reviews past work with mathematics curricula, particularly in West Africa, especially looking for early participation of classroom teachers; and also considers theoretical writings on the curriculum implementation process.

The experiment measures the intercorrelations of (1) participation in curriculum development, (2) knowledge of new curricula, and (3) attitude toward curriculum change among mathematics teachers in the teachers' colleges of Benue, Kaduna, and Sokoto States; and then measures any changes in these variables following the attendance of teachers at a workshop specifically directed to familiarizing them with the new mathematics curriculum.

The study seems necessary to fill an important gap in curriculum research at a crucial time for application of the expected results. The following four points briefly review the need for this study:

(1) Although there has been much work in mathematics curriculum development in West Africa, there has been little formal study so far of the processes involved.

(2) There has been even less study of curriculum implementation, even though that is where the process seems to have often broken down.

(3) The participation of teachers in the curriculum development process and their familiarization with new curricula appear to be important positive factors in successful curriculum implementation, but this is largely untested conjecture, especially in Nigeria or other developing countries. Empirical data are needed to meet the challenge posed by the administrative difficulties of such teacher involvement.

(4) The time is ripe for such a study since new mathematics curricula for Nigeria are now reaching the implementation stage.

It is hoped that recommendations derived from the results of this research can be of service not only to the current effort of mathematics curriculum implementation, but also to other similar efforts and to the general study of curricula.

Chapter 2

SURVEY OF LITERATURE

2.1 Outline

This study of implementation of mathematics curricula was initially motivated by interest and concern for the implementation problems encountered by the various "modern mathematics" curricula in West Africa. Therefore, this survey reviews some of these curricula, their associated implementation processes, and related developments in mathematics education in West Africa since about 1960. This review is preceded by a brief summary of the development of mathematics education, especially in Western education, over the past two centuries, with emphasis on changing curricula, to provide a background for the more recent events.

However, the historical background and even the latest developments provide only the setting for the present study. The theoretical foundation is found in academic studies of curriculum change and models of the diffusion of educational innovations. Discussion of relevant studies in these areas forms the next major section of this chapter. This should give an indication of the point of departure for the present study.

The chapter closes with a section covering studies which provide guidance on the procedures for this research. Included are content studies of attitude change and the population being studied here; methodological references on the instrument design and statistical treatment; and other reports and recommendations which form a context for the findings of this study.

2.2 Mathematics Curriculum Development

2.2.1 Mathematics Curricula Before 1900

Although mathematics is very old, mathematics education as a separate discipline for serious discussion of appropriate mathematics curricula is mostly a product of the present century. Griffiths and Howson (1974) describe the mathematics curricula of some of the early common schools. Many of the early schools concentrated on "ciphering" with only a few covering the geometry theorems of Euclid. Gradually the demands of science and navigation and the growth of industry brought more mathematics into the curricula; however higher-level mathematics was still limited mostly to specialized military or technical schools. Several writers of the time, notably Colburn (1830), Wentworth (1885), and Seeley (1888) (all reprinted in Bidwell and Clason (1970)), discussed the methodology of mathematics teaching, but there was little discussion of mathematics curricula until the last decade of the century.

2.2.2 Mathematics Curricula: 1900-1950

2.2.2.1 Moore, Perry, and Commissions: By the 1890s, the growth in the number of schools in Europe and America and the realization by some mathematicians of the growing gap between school mathematics and mathematical research, led to a new concern for improving the mathematics curriculum. Griffiths and Howson (1974) and Jones (1970) both provide much historical reporting of this period while Bidwell and Clason (1970) offer a collection of reprints of many of the actual writings and reports. Several committees and commissions made recommendations for improvements in the mathematics curriculum such as including algebra and geometry in syllabuses that previously had covered only arithmetic. Bidwell and Clason (1970) point out that initially the committees were mostly composed of university mathematicians and school administrators. It is also interesting to note, as Griffiths and Howson (1974, p.19) point out, that contributors to reports, in several cases, later became textbook writers, including the well-known C.V. Durell. Besides the committees and commissions, several individuals made statements and suggestions for curriculum improvement. David Eugene Smith (1904) and J.W.A. Young (1906), often considered the first mathematics educators, both wrote on the teaching of mathematics and the mathematics curriculum (both reprinted in Bidwell and Clason (1970)). Eliakim H. Moore (1902), devoted his presidential address of the American Mathematical Society (also in Bidwell and Clason (1970)) to his concern for school mathematics, and especially the need to break down the compartmentalization of topics and to look for more links between mathematics and science. The British engineer, John Perry, had made similar comments at the 1901 meeting of the British Association for the Advancement of Science (1902; also in Bidwell and Clason (1970), and discussed in Griffiths and Howson (1974)), with a particular call for more stress on the usefulness of mathematics, not just for passing exams, but also for science, for logical thinking, for everyday applications, and for "mental pleasure".

2.2.2.2 The 1923-Report: Perhaps the most comprehensive and far-reaching recommendations came in the report of the Mathematical Association of America's National Committee on Mathematical Requirements (1923, partially reprinted in Bidwell and Clason (1970)), the so-called "1923-Report". It recommended stronger programmes for junior-high schools, more use of intuitive geometry and trigonometry, greater unity of content through the concept of function, and more careful use of mathematical terms and symbols.

2.2.2.3 Psychology and Efficiency: However, the good intent and significant recommendations of the 1923 Report were not to be implemented quickly. Other, external events greatly muted the impact of the Report and few of its ideas were accepted for over thirty years. Psychology and educational measurement had come upon the scene. Connectionist psychology, as advocated by Thorndike (1924), was very concerned with breaking learning down to minute pieces or "elementary bonds". In the process, much of the logical structure and the interrelationships of various parts of mathematics was lost. Osborne and Crosswhite (1970) discuss this effect of psychology on mathematics education and also the related emphasis on efficiency.

Efficiency fitted in well with the psychologists' interest in measurement and also was related to the growth of business and commerce in the 1920s. Efficiency in education meant avoiding waste in terms of time and labour as much as in maintaining an economical business. Anything that could be trimmed from the curriculum to make for more efficient teaching would be removed. Mathematics beyond the most elementary had trouble justifying its place in this tight curriculum. The strict interpretation of usefulness became even more severe as the industrial world fell into the serious economic depression of the 1930s. Writers on mathematics education of the time stressed the need for mathematics that had social utility. For example, Metter (1933) advised that the main objective of school mathematics should be practiced with "social arithmetic"; Klapper (1934) warned teachers not to over-do mathematics that is never needed in adult life; and Bowden (1929) did research on what mathematics topics adults did in fact use. Since it seemed that people could get by with a very minimal amount of mathematics, mostly basic arithmetic, the mathematics curriculum was trimmed until it almost disappeared. Society had called for austerity and the curriculum responded.

2.2.2.4 World War II and Post-War Plans: When World War II burst forth, science and technology, more than ever before, became essential weapons in the fight. Soldiers had to handle increasingly sophisticated devices and often the trimmed-down mathematics they had studied in school did not serve them well enough. Hart (1941) worried that remedial programmes could not make up for lack of strong understanding of the fundamentals. As the war drew to a close, the Commission on Post-War Plans (1945) issued a list of thirty-four recommendations, covering all levels of schooling, which discarded the idea of incidental learning of mathematics, called for more emphasis on understanding and better handling of drill, and asked for much stronger programmes in secondary mathematics. The almost-forgotten recommendations of the 1923 Report were recalled and reiterated. After a pause for a quarter-century, mathematics education would grow again. The stage was set for "modern mathematics".

2.2.3 The Start of "Modern Mathematics"

2.2.3.1 UICSM: By the early 1950s, the industrial world was in the midst of unprecedented technological growth and development. The weaknesses of the limited, "practical" mathematics of the previous decades had become apparent beyond the needs of wartime soldiers. Osborne and Crosswhite (1970) point out many articles from the 1950s which criticize the older curricula and call for much more emphasis on mathematics, especially for the above-average students, to produce more high-level manpower for science, technology, industry, and government.

At the University of Illinois, this concern focussed on the weak mathematics background that was noted in first-year degree students in engineering. A committee was organized, with representatives from the engineering, mathematics, and education departments of the university, to see what improvements could be made in the secondary mathematics curricula, especially for students who would need a strong mathematics background for university work. The result was the University of Illinois Committee on School Mathematics (UICSM), generally regarded as the first of the many mathematics curriculum revision projects that were collectively labelled "modern mathematics" (This term is discussed in Sections 1.5.2 and 2.2.4.4).

The history, philosophy, and products of UICSM are described by Osborne and Crosswhite (1970), including further references, and, more directly, by UICSM (1956) and the statement by the project director, Beberman (1958). The UICSM worked on the assumption that true mathematics learning and, in fact, creativity in general, comes from a child's desire to systematize his knowledge. Therefore, the two main themes of the project were the need for precision of language and discovery of generalizations.

The first materials of the UICSM were tried in the University High School and other nearby schools. It soon became apparent that "High school teachers of mathematics, although receptive to these new ideas and anxious to incorporate them in their teaching, are not prepared academically to teach concepts from contemporary mathematics. However, they are capable of doing so when they are given appropriate help both in understanding these ideas and in teaching them". (UICSM (1956) quoted in Bidwell and Clason (1970 p.660)) This belief in the need for familiarizing teachers with new material, here stated in the earliest "modern mathematics" programme, was repeated many times later.

2.2.3.2 Slow Diffusion: Such familiarization with new developments can be a slow and difficult process. Three years after UICSM got underway the influential National Council of Teachers of Mathematics (NCTM) published a yearbook titled Emerging Practices in Mathematics Education (NCTM, 1954), but, as Osborne and Crosswhite (1970) point out, even this publication from a leading organization seems woefully ignorant of the practices that really were emerging, and instead, mostly repeated ideas and practices from the 1930s and 1940s. There was little hint of the revolution already getting started at the University of Illinois, other universities, and in the planning committees of various mathematics organizations.

2.2.3.3 CEEB Report: Another step toward major revision of mathematics curricula came in 1955 with the formation of the Commission on Mathematics by the College Entrance Examination

Board (CEEB). It was to be four years before the Commission's report (Commission on Mathematics, 1959) would be published, but preliminary reports and drafts were circulated earlier and began influencing the curriculum revision efforts. The Commission included school mathematics teachers and university mathematics educators, as well as mathematicians. Most of the report covers the recommendations for new content and rearrangement of the topic sequence, but also it recognizes the importance of the teacher and his presentation of the material. "A poor curriculum well taught is better than a good curriculum badly taught. A good curriculum well taught is the only acceptable goal." (Commission on Mathematics (1959) p.6; also Bidwell and Clason (1970) p.673). One entire chapter of the report was devoted to "Implementation: the vital role of teacher education" and, as the title indicates, it considered pre-service and in-service preparation of teachers as the essential ingredient to successful implementation of new curricula.

2.2.3.4 UMMaP: The late 1950s saw the start of several projects of new school mathematics in the United States, notably for this study the University of Maryland Mathematics Project (UMMaP), which involved recruiting junior-high school mathematics teachers, giving them a one-term in-service course of advanced mathematics topics, and then inviting them to join the project's staff in preparing new materials for junior-high mathematics. Other projects developed programmes specifically for local needs, and some were beginning to pick up ideas from UICSM and from the preliminary work of the CEEB Commission on Mathematics.

2.2.3.5 Sputnik: As an additional stimulus for new work to improve American science and mathematics education, in October, 1957, the Soviet Union began the "space race" with the launch of the first earth satellite, Sputnik. Some have pointed to this event as the start of the "modern mathematics" campaign, and to some extent the shock of it did give an extra impetus to the efforts and probably helped generate much more funding than would have otherwise been available. However, it should be clear from the above account that the foundations of "modern mathematics" had already been laid even a decade before Sputnik.

2.2.4 SMSG and Later "Modern Mathematics" in the United States

2.2.4.1 Organization of SMSG: The biggest - most extensive and most productive and probably most influential - "modern mathematics" programme was launched in 1958. It was the School Mathematics Study Group (SMSG). The SMSG was also significant as it was established by the American Mathematical Society, a group of pure mathematicians which, as an organization, had virtually ignored the problems of school mathematics for several decades. Besides its many texts and course outlines, the SMSG published several outlines of its philosophy and techniques; e.g. SMSG (1959), SMSG (1965); its director, E.C. Begle also wrote reviews of the project's work, Begle (1962) and Begle (1968); and Wooten (1965) presents an official history of the early years of the project; Osborne and Crosswhite (1970) also discuss SMSG's development quite extensively. These references are discussed below.

2.2.4.2 Role of Teachers and Trials in SMSG: Of particular interest here is the participation of teachers in the development of SMSG materials and in the implementation of SMSG products. The organizers of SMSG were research mathematicians, but even the first writing workshop, in the summer of 1958, consisted of twenty-one mathematicians, twenty-one secondary school teachers and supervisors, and a few others representing organizations which use mathematics and need mathematically-trained manpower. This balance was to continue. Mathematicians and teachers would each offer their own ideas of proposed school mathematics presentations, and the resulting text would represent a consensus of opinions after discussion and exchange of views. Partly from this effort for consensus, SMSG tended to reject the most radical proposals, and moved cautiously for fear of causing the ordinary classroom teacher to be left behind.

Also starting from the first work in 1958, SMSG materials usually followed a pattern of having a trial edition worked out during one summer, trying the material in classrooms during the following school year, gathering evaluative comments from the teachers who used the material, revising it based on these reports and reactions during the next summer, and often following this up with more trial use.

Begle (1963) pointed out that along with the basic objectives of an improved curriculum for better basic understanding of mathematics and greater student interest in mathematics, a concurrent goal was "to prepare materials for the preparation of teachers to enable them to teach such an improved curriculum" (Begle (1963) p. 140). Along with printed materials to aid teachers, SMSG established centres for direct teacher consultation in various locations.

2.2.4.3 Later SMSG: The goals of SMSG did not foresee a series of "official" SMSG textbooks in use in classrooms, but rather that SMSG materials serve as models for other writers for commercial publication. Several SMSG writers left the project to write their own texts - with full encouragement of SMSG. However, even without a desire for direct implementation, the SMSG programme involved so many people - tens of thousands of teachers and students - in the various stages of its development and trial use, and so much effort was made to assist the teachers with its use, it became one of the most successfully implemented of all the American "modern mathematics" programmes.

Moving through the 1960s, the SMSG expanded from its initial target of university-bound secondary school students, to also include curricula for primary schools and for average and below-average students and to support wide-ranging research in mathematics education, including the five-year-long National Longitudinal Study of Mathematical Abilities, which involved 120,000 students.

2.2.4.4 Other U.S. Projects: Also, the 1960s saw many other mathematics curriculum projects in the United States. Several sources offer summaries and comparisons of the various projects: NCTM (1961), NCTM (1963), Scott (1966), Seyfert (1968), Sherman (1972), and others. The projects had several different starting places and different emphases. Some stressed the idea of sets; others chose to use algebraic ideas and the use of symbols. Some attempted a very concrete presentation; others used mathematical rigour and abstraction.

Geometry was treated as a revised version of Euclid's work; or with emphasis on symmetry and transformations, or as a coordinate system, or various combinations of these. Neary all called themselves "modern mathematics" (or "new math"). For some, their only claim to "modernity" was the insertion of a chapter on sets or non-decimal numeration, or the use of non-standard teaching aids in an otherwise "traditional" text. Wren (1971) criticized pseudo-"modern Mathematics" texts that carried such trappings of "new" topics without changing their approach. Such variety, all under the label of "modern mathematics' was confusing and even self-defeating in the effort to make significant changes in the mathematics curriculum.

Although the focus of the present study now moves away from the American programmes, it is worth noting that the 1970s brought considerable discussion and complaints about some of these programmes. Kline (1973) made the first major critique, followed by many other essays (e.g. Vogeli (1976)); research reports (e.g., the National Advisory Committee on Mathematics Education (NACOME), Conference Board of Mathematical Sciences (1975), and Athappilly (1978)); and overviews of the developments (e.g., Tanner and Tanner (1975), Fey (1978), McGarvey (1981), and others).

2.2.5 "Modern Mathematics" in Britain

2.2.5.1 SMP: The explosion of curriculum revision projects in the United States was actually part of the worldwide movement for new mathematics programmes in the schools. In Britain, as in America, the effort yielded several major projects and many smaller, local programmes. Some of the projects are described in general reviews, such as Mathematical Association (1968, revised 1976), Watson (1976), and Howson (1978). Three projects for particular mention here are the School Mathematics Project (SMP), Nuffield Primary Mathematics Project, and the Mathematics for the Majority project.

The School Mathematics Project (SMP) has been the biggest and longest of the British mathematics curriculum projects. It began in a group of eight schools in 1962 and still continues to produce materials more than twenty years later. It was originally aimed at above-average students for O-level examinations, though like the SMSG in America, the SMP materials were later revised for less academic students and also the programme was expanded to include a wide variety of texts and workcards for primary schools. It should be noted that SMP was originally started by teachers who were unhappy with the mathematics syllabus that then existed. Although the organization grew very much, SMP tried to maintain close links with classrooms. Teachers formed the largest part of the writing committees and materials were modified in response to feedback from trial versions (Watson (1976) pp. 19-20).

2.2.5.2 Nuffield Mathematics: Perhaps an even stronger commitment to involving teachers, and especially to familiarizing them with the new materials, was seen in the Nuffield Primary Mathematics Project. Nuffield did not produce any textbooks and only few other materials for direct pupil use. Nor did Nuffield attempt to design or follow any specific syllabus. Rather, it prepared a variety of teachers' guides, full of teaching suggestions for the new material. Even more significant was the establishment by the Nuffield organization of "teacher centres" scattered all over Britain, where teachers could come together to discuss their teaching of the Nuffield material with specialists and, more important, with each other. The teacher centres were so successful that they were later expanded, with help from other educational authorities, to help teachers in other subject areas. In addition, Nuffield sponsored courses, conferences, newsletters, films, and television productions with almost all of them aimed at teacher-training. Not only had it brought about important changes in primary mathematics, but it had done so in such a way that even generalist primary school teachers had followed its direction with comprehension and enthusiasm (Watson (1976) pp. 61-62).

2.2.5.3 Mathematics for the Majority: Following much the pattern as Nuffield had established at primary level and aiming at students who had been initially overlooked by SMP, the Mathematics for the Majority programme tried to help teachers bring valuable mathematics to average and below-average secondary students. An important finding in the project's preliminary research showed that about one-third of the average students and over half of the below-average students were being taught mathematics by teachers who were not mathematics specialists (Watson (1976) p.77). This presented a special challenge - to reach those non-specialist teachers and to get them involved in the design, feedback, and evaluation of the new materials. Again, the emphasis was on teachers' guides rather than textbooks and many conferences and workshops and other face-to-face contacts were organized.

In the extension of the original programme (called Mathematics for the Majority Continuation Project (MMCP)), classroom teachers were the major source of ideas for the curricula materials, organized into over forty writing groups.

This further emphasized "that only classroom teachers were in a position to construct suitable materials for a large proportion of the pupil population" (an MMCP statement quoted in Watson (1976) p.90). But the materials were intended to be further developed as they were used, and teachers, especially those who had not worked on the project, still needed help. The project's work led to the realization that the development work may be lost without widespread distribution of materials and a continuing programme of teacher assistance, long after the initial development.

2.2.5.4 Howson's Overview: Howson (1978) offers a careful retrospective analysis of British "modern mathematics". Besides describing the organization, objectives, and history of the projects mentioned in this section and other programmes, he emphasises the often over-optimistic goals of the projects and the difficulties and disappointments in attempting to attain them. He makes particular reference, throughout the article, to the importance of the individual classroom teacher: the advantages of using teachers as writers; the need to familiarize all the teachers and especially the non-specialists; and the implementation problem of the independent teacher who teaches new curriculum material according to his own ability, experience, methodology, and interpretation.

2.2.6 "Modern Mathematics" around the World

2.2.6.1 Reports: Howson's (1978) report on mathematics curriculum change in Britain (Section 2.2.5.4) is one out of sixteen country-by-country reports published in Educational Studies in Mathematics (Freudenthal (1978a)) in a special two-issue survey of mathematics developments around the world. This offers one of the most detailed and comprehensive commentaries of this movement currently available. Lockard (1963-1977) is also very comprehensive, offering specific "fact-sheet" information on many individual projects in science and mathematics education from various countries in the form of ten up-dated reports over the fifteen-year period. Other reports about worldwide mathematics curricular developments appear, usually referring to only one country, in various journal articles and papers presented at international conferences, some of which will be noted below.

2.2.6.2 Examples: The movement for change in school mathematics quickly spread around the world. Often, the new curriculum work was the translation, adaptation, or straight adoption of new programmes from elsewhere. For instance, the SMSG materials from America (Section 2.2.4) were translated into Spanish for use in Peru, formed the model for the programme of India's Central Board of Secondary Schools, and were directly used in some states of Australia. Similarly, SMP (Section 2.2.5.1) and occasionally UICSM (Section 2.2.3.1) materials went around the world.

Most European countries and other countries with long-established education systems organized their own programmes of curriculum revision in mathematics, and nearly all reported that teacher training and teacher support were major problems of implementation. Revuz (1978) discussed the French view that two main problems were to be solved: bringing school mathematics closer to the recent developments in mathematics, and giving students a stronger conceptual base for the increasingly wide use of mathematics. To help teachers meet these goals in their teaching, a network of Instituts de Recherche sur l'Enseignement des Mathématiques (Mathematics Teaching Research Institutes - IREM) was established, similar to the Nuffield Teacher centres (Section 2.2.5.2) in Britain, but with stronger institutional links and oriented to continuing research in mathematics instruction as well as providing aid to teachers. The IOWO (Institut Ontwikkeling Wiskunde Onderwijs - Institute for the Development of Mathematical Education)(Freudenthal (1978b)) served much the same purpose in the Netherlands.

A less structured approach to spreading new curriculum information and ideas could be described as "organic" or perhaps "each-one-teach-one". A new programme would be introduced in a few geographically scattered pilot schools. Each one served as an example for neighbouring schools and gradually the innovation would spread over the whole area. Hungary (Halmos and Varga (1978)), already known for excellence in mathematics and mathematical problem-solving, did not jump onto the "modern mathematics" bandwagon, but instead used a slower, more gentle process such as this. A variation is to invite a few selected teachers to attend familiarization workshops or to receive special training in the use of new materials. Then each goes out to organize local workshops in his own area or to set up other ways of informing his nearby colleagues of the coming changes. Sri Lanka (Jesson, 1970) used such a chain of multiplying workshops. In the Philippines, this pattern has been called "echo-workshops" since the participants are all expected to echo what they learned at the workshop, passing it on to their colleagues at home (personal communication).

2.2.6.3 Newly Independent Countries: In many countries which had newly gained independence in the 1960s, the general problems of curriculum development and implementation were compounded by issues arising from the new independence. When colonial government ended, there were calls to change education systems and curricula which had been established by the colonialists.

However, even with foreign governments gone, foreign advisors and foreign funding continued, especially in the early years of independence, and made considerable contributions to curriculum development. Howson (1969) lists some of the British sources of aid. American aid included funds from the Agency for International Development and the National Science Foundation, Peace Corps teachers and curriculum aides, and private assistance such as that from the Educational Development Corporation which is described in Section 2.2.8.2.

The discussions on curriculum centred on developing local textbooks and, at a deeper level, designing curricula to better reflect national needs and goals. In mathematics, this tended to go in two directions: increased emphasis on fundamental processes and basic concepts with increased locally practical applications; and, at higher levels, increased support for mathematics for developmental applications in civil engineering, new technological industries, and agriculture.

Also, concerns were expressed about the cultural relevance of mathematics curricula. Although mathematics may be considered more universal in content than most subjects, different cultures do look at quantity and spatial relationships in different ways and have varying applications of mathematics (See also Section 2.2.7.1). Johnson (1970), referring to Chinese culture in Malaysia, notes the need for mathematics curricula and instructional patterns to reflect local understandings of mathematics. As a more specific example, Wolfers (1971) recommends the use of the complex local numeration system in teaching arithmetic in Papua-New Guinea. Similar concerns of linking school mathematics to local culture in Africa are discussed in Section 2.2.7.2.

Swetz' (1969) description of the problems of mathematics education in Malaysia sounds similar to those of former British colonies of Africa, including the use of the same familiar textbooks (e.g., C.V. Durell's series). He points to the need for stronger mathematics teacher organization, for locally-written texts, and revisions of the Cambridge examination system used there.

Writers from Papua-New Guinea discuss similar problems and introduce the kind of controversy that broke out when attempts were made to adopt "modern mathematics" rather directly in developing countries. Allen and Shannon (1970) briefly described the Science Education Project (SEP) which included both mathematics and science materials. They described SEP as aiming at individual needs and also drawing on "modern mathematics" developments such as using set theory in geometry and introducing topology. Deakin (1971) strongly urges much more emphasis on "service mathematics" and practical skills. He doesn't mention SEP directly, but describes "modern mathematics"-type programmes in Papua-New Guinea as mostly useless, and specifically criticizes topics of sets and topology. He writes that Papua-New Guinea does not need mathematics theoreticians, but local engineers and ordinary citizens with skills in calculation, measurement, and basic statistics.

In addition to the growing "modern mathematics" debate, many countries in the developing world were trying to greatly expand their school systems, further adding to problems of curriculum improvement with shortages of supplies and especially of qualified teachers. Once again, as in the case of the richer countries, the problems of curriculum development and implementation became tied with the problems of teacher education. In developing countries with rapidly growing educational systems and serious shortages of qualified mathematics teachers, the problems were much more intense and curriculum development was to become much more closely entwined with teacher education.

A very good example of successfully using this interrelationship between curriculum development and teacher training was the Caribbean Mathematics Project, reported in Cundy (1977). This project, involving much cooperation from eight islands of the Lesser Antilles and funding and advisory support from several different foreign and United Nations aid agencies, developed teaching modules and teacher guides in mathematics for junior secondary schools. They centred their content around the Joint Schools Project (Mitchelmore and Raynor (1968-72)) mathematics textbooks, which were developed in Ghana and are discussed below (Section 2.2.9.1). However, the distinctive feature of the Caribbean project was the great extent of teacher participation - even among less-qualified teachers - in the actual writing and testing of the modules. This was largely done through the organization of local single-island workshops attended by teachers and consultants. Besides creating good classroom-based materials, the system built up an experienced and enthusiastic team of teacher-curriculum developers throughout the islands. In this way,

> the project aimed to take the weakest feature of the Caribbean educational scene - the lack of trained teachers - and turn it into the strongest by proving to teachers that they had within themselves the power to develop skills of constructing lessons, writing materials, organizing syllabuses which could respond to the changing eventualities of a rapidly developing world. (Cundy (1977) p.7)

2.2.7 Mathematics in Africa before 1960

2.2.7.1 Studies of African Mathematics: The wave of mathematics curriculum revision efforts swept into Africa in the early 1960s, accompanied by many of the same difficulties that have been reported elsewhere. As mentioned above (Section 2.2.6.3) for Malaysia and Papua-New Guinea, the new programmes in mathematics must be considered in the context of the existing colonial - and even pre-colonial - education in mathematics. However, there is very little historical research available about school mathematics curricula in colonial Africa. Most reports (one of the most comprehensive is the Phelps-Stokes Report (Lewis (1962); originally 1922, 1925)) and histories (such as Coleman (1958), Fafunwa (1974), and Ozigi and Ocho (1981)), describe mathematics only as one of the many areas of schooling which they discuss. Raum (1938), while somewhat patronizing in its language, does describe some interesting links between traditional mathematics and the mathematics of Western education. More recent research, such as Zaslavsky (1973), shows further links, and Okoro (1974), Enukoha (1980), and Adaaku (1982) make similar studies, focussing more specifically on mathematics in the traditional cultures of the Ibibios, the Igbos, and the Tivs, respectively. Gay (1967), Gay and Cole (1967), and Col et al (1971) have contributed significantly to the theory of learning school mathematics vis-à-vis the traditional mathematical concept in Liberia.

2.2.7.2 Applications in African School Mathematics: Applying this kind of knowledge to curriculum design, Morley (1969) urges that teachers and curriculum developers - both indigens and expatriates - need more background and understanding of the life and culture of the students for better choice of examples and presentation of curricula material.

Hill (1966) expresses concern over subtle but serious misconceptions that could arise in translating mathematical ideas from English to African languages. She is particularly worried when teachers use English teachers' guides and then, using their own, usually untrained, interpretations, teach in the local language. Perhaps increased input from local teachers in the original design of the curriculum materials would help to reduce this problem.

As a specific example of linking mathematics curricula to local needs, Lassa (1983) offers suggestions for mathematics in Primary 1. He makes reference to local number games, traditional systems of measurement, and concept of area and volume. Often such local detail require intimate familiarity with the school's cultural context. It may be that the teacher's knowledge is the best source of this familiarity.

However, prior to the 1960s, nearly all textbooks in Africa were imported. Badmus (1977) reports on textbooks in use in Nigeria in the 1940s and Nwagwu (1981) scans the history of mathematics education in Nigeria from about that time up to 1980. An interesting point is that, even as Britain experimented with new mathematics programmes, many old British textbooks, only slightly revised from the 1940s continued to be used in Nigeria well into the 1960s and even the 1970s. Hawes (1979) makes the same point for primary curricula in general.

2.2.8 African Mathematics Programme (Entebbe Mathematics)

2.2.8.1 Sources of Information: The first and largest "modern mathematics" project in Africa was the African Mathematics Programme (AMP), which produced the Entebbe Mathematics Series (1962-1969). A full, objective history and assessment of the AMP has not been made, though Shirley (1979) made a start, Ohuche (1978) covers much of the development of the programme, and the programme is included in the fifth though the ninth Clearinghouse reports of Lockard (1967,-1975). Several internal reports, notably Collard (1964); Ukeje (1965), Martin and Aldrich (1966), Bradley (1966), and G. Williams (1974), discuss parts of the programme, and some external observers also comment on the programme;

e.g., Pretty (1965), Weaver (1965, 1966), Potts (1967), Wilson (1969), and, in most critical detail, Hawes (1979). These are the sources of the information in the following sections.

2.2.8.2 History of Entebbe: The African Mathematics Programme was initiated by Jerrold Zacharias, through the American-based Educational Services, Incorporated (ESI, later renamed Educational Development Center, EDC) following discussion with African scientists and educators at the International Conference of Science in the Advancement of New States in 1961. Zacharias and EDC were already very much involved in curriculum development projects, notably the Physical Science Study Committee (PSSC) (see Section 2.2.4.1). Following some planning meetings in the U.S. and in Ghana, of American and African mathematicians and educators, the first of a series of annual summer writing workshops was held in Entebbe, Uganda, in 1962. The programme eventually produced textbooks and teachers' guides for all classes of primary and secondary schools and teacher training colleges, as well as various handbooks and syllabus guides (Entebbe Mathematics Series, 1962-1969).

Following the example of the SMSG, the AMP intended that its materials would serve as models for individual regional, national, and local projects. The West African

Regional Mathematics Programme (WARMP) in Ghana, Liberia, and Sierra Leone; and the East African Regional Mathematics Programme (EARMP) in Kenya and Ethiopia represented cooperative regional efforts to adapt the materials for use in their areas. On the national level, Ethiopia took the Entebbe materials and produced its own secondary and Amharic-language primary texts which were put into use in all the schools in the country.

Probably the most successful local adaptation of Entebbe Mathematics was the Lagos Modern Mathematics Project (LMMP), under the direction of Grace Alele Williams. Starting as a trial project in a few primary schools, it eventually became the basis for the state-wide primary mathematics syllabus, which was mostly prepared by teachers who had received special training as a part of the LMMP implementation (see also Sections 2.2.8.3 and 2.3.7.4).

2.2.8.3 Participation and Familiarization of Teachers: There are contradictory strands in the story of the involvement of classroom teachers in the AMP work. The initial planning and much of the early writing was done by a group who were mostly university mathematicians and Ministry of Education officials, not immediately familiar with school classroom situations or the actual abilities of students. As a result, complaints soon arose (e.g., Potts (1967), Wilson (1969), and oral complaints expressed at teacher workshops conducted by the researcher in the early 1970s) that Entebbe Mathematics, especially the secondary school material, was too axiomatic and over-rigorous and had too much reading material, especially for students reading in a second language.

On the other hand, once the material was prepared, the developers of AMP made considerable effort to train teachers in its use through direct workshops and the so-called "ABC Institutes" to prepare teacher-trainers to hold more local workshops. Also, the later outgrowths of the original Entebbe programme, such as WARMP, EARMP, and LMMP, seem to have noted some of the earlier complaints, and strived to involve teachers much more in the writing and revising of the newer material. In particular, G. Williams (1974) describes considerable teacher participation in the development of the LMMP and the resulting successes of implementation (see Section 2.2.8.2 and especially 2.3.7.4).

But, still, as the number of schools using the material grew, and more and more local and state educational authorities hurried to join the "modern mathematics" trend, there were more cases of rapid adoption of the texts without the necessary preliminary familiarization and teacher-training. Many teachers from different parts of Nigeria and Sierra Leone complained to the present writer of feeling confused and helpless in the face of announcements of immediate changeovers to Entebbe or other similar curricula.

Even as teachers began to object to the content, presentation, and implementation of the AMP curricula, these very objections began to lead toward the realization of one of the initial goals of AMP: that of stimulating others to prepare new curricula in mathematics. Several new projects were organized by teachers and others who desired change in the mathematics curriculum, but who were unhappy with the results of the Entebbe work. As Hollingshead (1968) pointed out, the competition was good, for it gave teachers and ministries of education a wider range of programmes to choose from to better match their own needs.

2.2.9 JSP and Other "Modern Mathematics" Programmes in West Africa

2.2.9.1 Joint Schools Project: The Joint Schools Project (JSP), probably the most successful mathematics curriculum project in West Africa in the late 1960s and early 1970s, was one of the reactions to the Entebbe curricula. The programme was initiated by secondary school teachers in Ghana, originally as a sub-committee of the Mathematical Association of Ghana. Descriptive reports on JSP are found in Lockard (1968, 1970, 1972, 1975), Mitchelmore (1967), Mitchelmore (1971), and Howson (1972); Potts (1967) compares JSP with other contemporary programmes in West Africa; and Shirley (1975) makes suggestions for improving the then ten-year-old programme.

The JSP developers specifically pointed to their emphasis on mathematics that was appropriate, relevant, and accessible to their students, including much practical work, and relying on intuitive understandings, "since experience has shown that over-emphasis on logic kills all interest and hinders progress" (Lockard (1972) p.42). Teachers, working in their spare time, did much of the writing and the initial small scale of implementation allowed the use of thirty schools for trial use of the materials. Formal preparation of teachers who were not involved in the development was generally handled through the Ministry of Education and much informal consultation between schools was supported by the Mathematical Association of Ghana. Also, the British Council and the American Peace Corps provided additional support for teacher-training and introduction of the programme into schools. Soon after the JSP programme started, it also spread to trial schools in Sierra Leone and Nigeria and, as the books began to be commercially available, they became widely used in these countries. Similar efforts at teacher preparation were again handled by the respective Ministries of Education and Mathematical Associations, often through workshops and school visits. Eventually the programme was so successful that new editions were planned for the Caribbean (mentioned in Section 2.2.6.3), Central Africa and even Malaysia. Overall, JSP exemplified curriculum development from the level of the classroom teacher rather than from a big organization. This approach at once made it more difficult to get financial support and yet closer to the source of the problems.

2.2.9.2 Syllabus Changes and Other Programmes: In 1967, the West African Examinations Council approved the Entebbe syllabus for O-level examinations and the JSP syllabus gained approval in 1969, both as independent alternatives to the older syllabus in mathematics. In the early 1970s, a consolidated syllabus called "Modern Mathematics" was offered by the Examinations Council. This was drawn largely from the JSP Syllabus, but with slight modifications to make it applicable to Entebbe also. In addition, it accommodated several other independent "modern mathematics" programmes that had been prepared, mostly by commercial publishers and mostly in Nigeria, and stimulated work on several more. By 1976 there were probably a dozen or more secondary-level "modern mathematics" programmes available in Nigeria. A few of the most popular were Ferris and Busbridge (1967, 1972, 1973), Dada and Josiah (1973, 1975), and Adelaja _et al_ (1976). Also, most commercial publishers offered "modern mathematics" textbooks for primary schools.

2.2.9.3. Teachers' College Mathematics, c.1970: Generally teachers colleges were only doing arithmetic and often continued to use old upper-standard primary arithmetic books as their texts. As the schools began doing more mathematics, there were some questions as to which texts were appropriate. Some used the same texts as were in use in the secondary schools. In the then Northern Region of Nigeria, later (1967-1976) the six northern states, an American-supported aid project also organized considerable developmental work for the teachers' college curriculum (Lockard (1968)). The Northern Nigeria Teacher Education Project, working through the various Ministries of Education, and based in six northern teachers' colleges, prepared curricula in several subject areas, including mathematics (Northern Nigeria Teacher Education Project (1969)), and attempted to draw together contributions both from classroom teachers (most of whom also received additional training in the process) and experts (foreign and local) in mathematics and educational theory. Lassa (1975) discusses the teachers' college mathematics curricula on the early 1970s.

2.2.10 Developments in Nigeria Leading to the 1979 Syllabuses

(Note: This section is based on a revision of parts of Shirley (1980b) which was written concurrently with the planning of this present study.)

2.2.10.1 Problems: Although Sections 2.2.8 and 2.2.9 show considerable progress in mathematics curriculum development in Nigeria, there were many problems behind the scene of successful change. There was the historical problem of the gap between the educational levels of the southern part of the country and the North - dating back to the colonial prohibition of Christian mission schools in Muslim areas (Coleman (1958)) - a problem which, in fact remains a challenge (Section 3.3.2). In mathematics, as in other subject areas, this disparity means a shortage of schools and an even greater shortage of teachers to man the schools in the North.

Another problem was the Nigerian Civil War of 1967-1970, which, among its other tragedies, led to the destruction of schools and the disruption of educational careers of many students in the zone of the war. Only when peace returned could the efforts of rebuilding make progress.

But probably the most immediate problem for the new mathematics programmes was the supply of teachers and their training. There was a general shortage of qualified mathematics teachers and often the schools had to rely on teachers with little more training or experience in mathematics and teaching than their students (see also Section 3.3.1.1). These teachers had to struggle enough even to teach the contents they had themselves endured as students. When new, unfamiliar material was imposed on them, they could not cope and had to either ignore the new topics or teach them by the same rote-memory, learn-the-formula techniques of the older programmes.

The early 1970s brought both good and bad news of mathematics education in Nigeria. Various local problems and dissatisfactions with the Entebbe Mathematics caused Nigeria not to join in the WARMP. However, the newly-organized Nigeria Educational Research Council held several conferences, planning sessions, and workshops on the new mathematics (as well as other topics). Also, the universities began offering various specialized Diploma and Degree courses, including some for mathematics education.

2.2.10.2 Universal Primary Education: In addition, the quintupling of the world price of oil in 1973 brought to Nigeria, as a leading oil producer, vast new sums of money for development. Money was now available for teacher training, curriculum development, more teaching supplies and instructional materials. But most significantly, money was available to attempt the long-cherished dream of Universal Primary Education (UPE). This massive undertaking, trying to raise primary school attendance to one-hundred percent nationwide from as low as less than ten percent in some northern areas, was a commendable goal. However, it became tied in with other national issues and had to be done in a rush. When it was announced in 1974, there was only two years of implementation time before the scheduled take-off for Class 1 in 1976. Hence, the job, big by the standards of any nation, became even bigger due to the tight timetable. Looking back after several years, Hawes (1983a), and Kelly and Lassa (1983) are critical of the lack of planning of UPE, especially in terms of financing and absorbing the output of the programme.

One result of the UPE seems to have been an exacerbation of the problems of school mathematics - efforts were directed more to greater quantity of students rather than higher quality of curricula and instruction, the shortage of teachers became more serious with the influx of pupils, and more students failed mathematics in their School Certificate examinations.

This was the situation in the mid-1970s and it has been reported in greater detail (with various emphases) by Fakuade (1973), Igboko (1973), Badmus (1976), and Ohuche (1978). The second half of the decade brought the UPE scheme to fuller operation (the first UPE group finished Class 6 Primary in 1982) and, in terms of numbers it not only brought education to many more children, it also began to close the educational gap between the North and the South. However, the problem of lack of facilities and staff remained serious.

2.2.10.3 National Policy on Education: Another development was the approval and publication of the National Policy on Education (1977). This document, produced by the Federal Ministry of Education after several years of discussion, sets forth the philosophical objectives of Nigerian education, describes a new structure of the years of schooling, and gives specific guidelines for various special areas of education. Some criticized the Policy for lack of detail on its implementation, and its Blueprint... (1978) of implementation seemed to come as an afterthought (Kelly and Lassa (1983)). However, it became the basic statement of the educational goals of Nigeria, including ideas for curriculum development work. It is worth noting the following objectives stated in the Policy:

(1) the inculcation of national consciousness and national unity;

(2) the inculcation of the right type of values and attitudes for the survival of the individual and the Nigerian society;

(3) the training of the mind in the understanding of the world around; and

(4) the acquisition of appropriate skills, abilities and competences both mental and physical as equipment for the individual to live in and contribute to the development of his society.

(National Policy on Education 1981) p.8)

2.2.10.4 "Modern Mathematics" Controversy: The third major development of the mid-1970s pertains more specifically to mathematics. This was the controversy over "modern mathematics" (The similar controversy in the U.S. is briefly mentioned in Section 2.2.4.4). Some writers, for example Iweha (1975), expressed valid curricular concerns such as the potential lack of preparation for the applications of mathematics in scientific areas. However, many of the complaints were not so much against the curriculum itself as against the results. The general public looked mostly at examination results which remained low and falling. The "modern mathematics" supporters who had pointed to low results in the older programmes found their arguments backfiring as the "modern" results were rarely any better. Some critics seemed to believe that "modern" and "traditional" mathematics were entirely different programmes with virtually nothing in common, though it was often pointed out that in a content analysis of the two syllabuses in use, the overlap was much larger than the distinctive portions. Others, more knowledgeable of curriculum trends, pointed to the growing criticism of "modern mathematics" in other countries, but often neglected to notice that most Nigerian programmes were very different and much more moderate than the programmes of high abstraction and mathematical rigour that were usually the target of Western criticism. Similarly, some criticized the new curricula as having been borrowed from abroad, even though most of the textbooks in use had been written in Nigeria, or at least in Africa. The problem that remained the central cause of poor mathematics results was still often overlooked: the shortage of qualified teachers of mathematics, and the lack of re-training to help teachers to understand and teach the new material (Fakuade (1980) discusses some of these points). Even though some efforts were made to organize workshops and short courses, many teachers still found themselves receiving directives to teach "modern mathematics" without any familiarization or special training - often simply because their educational authorities had wanted to appear progressive. However, as criticism from the public grew, the trend began to shift into reverse and supporters of "modern mathematics" were on the defensive.

In January 1977, mathematics educators felt happy to be called to Benin City by the Federal Ministry of Education for a conference. They expected the government wanted them to deliberate on the problems of mathematics education and offer advice on remedies. The Mathematical Association of Nigeria had already pointed to some of the basic problems including the need to reassess the objectives and content of school programmes and the requirement of more and better qualified teachers (for example, Osibodu (1976)). But the mathematics educators were shocked to hear the Federal Commissioner of Education announce that the government had already decided to abruptly cancel the teaching of "modern mathematics" and return to "traditional mathematics". The sensational announcement even received front-page, banner headline coverage: "Govt To Scrap Modern Maths" (Nigerian Herald, 1977).

Just as the economic depression of the 1930s had demonstrated the power of social and economic forces on mathematics curricula (Section 2.2.2.3), so this announcement showed that political forces, and especially military decrees, could seriously effect the course of mathematics curriculum development - beyond the control of educators.

The conference reacted strongly and issued a fourteen-page report challenging the Commissioner's arguements and pointing out what appeared to be the government's misunderstandings of the nature of contemporary school mathematics, criticizing the action taken without consultation, approving a list of objectives, and compiling a longer list of recommendations for curriculum development, smooth implementation, and teacher training (Report on the Mathematics Conference...., 1977).

2.2.10.5 Task-Force and CESAC: Mathematics educators, State Ministries of Education, textbook publishers, and especially classroom teachers were caught by surprise at the announcement. Some hesitantly continued with their current curriculum, while others scrambled to find twenty or thirty-year-old "traditional" textbooks. The best result was to push the National Task Force on Mathematics into quick action. The Nigeria Educational Research Council (NERC) had formed the Task Force in the previous July and some fact-finding committees were already at work in late 1976. But the news from the Benin Conference caused the Task Force to speed up its timetable, and it rapidly called a conference in February 1977. The Task Force approved further resolutions in reaction to the government's announcement, pointing out that the controversy had grown largely from lack of information on the rationale of the new curricula, that "traditional" and "modern" programmes differ more in approach than in content, that the shortage of teachers and the increasingly large number of students added to the problems of mathematics education, and that too often arguments against "modern mathematics" reflected personal biases rather than sound evaluation (NERC, 1977, pp.12-13). Furthermore, the Task Force commented on various related problems and issues (a broader range of pupils, the language difficulties, evaluation, the quality of teacher preparation, management problems, etc.) and made recommendations for dealing with those matters. Similarly, in a paper for the conference, G. Williams (1977) noted such problems as increased school population, the lack of adequate teacher-training, the non-permanence of teaching staff, and societal change as obstacles to the success of school mathematics programmes. More specifically, the Task-Force made detailed proposals for new syllabuses in mathematics for primary schools, secondary schools, and teachers' colleges. The group insisted that mathematics - not simply arithematic - be taught at all levels (NERC, 1977, pp. 12, 14, 15, 20-26).

Another independent effort considering school mathematics curricula, had been organized by the Comparative Education Study and Adaptation Centre (CESAC) at the University of Lagos. Starting in August 1976, CESAC held a series of conferences aimed at developing a new syllabus for secondary mathematics and planning a timetable for writing, trial testing, and teacher training. In October 1977, the National Council of Education, coordinating new syllabus development, asked CESAC to continue with its secondary syllabus work while the NERC was to work on syllabuses for primary school and teachers' colleges.

2.2.10.6 The 1979 Syllabuses: In early 1979, the Federal Ministry of Education approved and published the new syllabuses (Federal Ministry of Education, 1979). Once again, the task of implementation emerged as an even larger job than that of curriculum development. At the primary level, the large number of teachers to be trained made it necessary to ask State Ministries of Education to organize familiarization meetings and in-service training for teachers. Meanwhile, the NERC held several primary textbook-writing workshops and by 1981 had a full six-year series ready for publication. At the same time, some commercial publishers were also working on primary texts or modifying previous ones to match the new syllabus. At the secondary and teachers' college levels, the

Federal Ministry of Education held a series of week-long workshops to explain the programmes to some of the teachers. Commercial publishers quickly worked to produce textbooks for secondary level, though this effort has not yet (1983) progressed as far as the primary texts, and no teachers' college mathematics texts have yet appeared. However, the National Teacher Institute (NTI), which was given the responsibility for teachers' college examinations, has prepared some lesson "modules" based on the new syllabus, and the NERC plans some writing workshops to prepare mathematics textbooks for the teachers' colleges.

2.2.11 The Teacher Education Mathematics Curriculum

2.2.11.1 Current Thought on School Mathematics: Since the research uses the teachers' college mathematics syllabus in its implementation study, it is relevant to look at the syllabus in some detail. The content of the new syllabus (Federal Ministry of Education, 1979) reflects both the current world-wide trend in mathematics curricula toward more practical, applied mathematics and also the objectives of the National Policy on Education (1977). Around the world, reaction to excesses in "modern mathematics" brought calls for greater emphasis on basic skills such as calculation and measurement, plus everyday familiarity with geometrical properties and algebraic relationships. At a new extreme, in the opposite direction from "modern mathematics", some programmes following this "back-to-the-basics" trend eliminated all but the most basic arithmetic and returned to mechanical teaching approaches and very limited goals of minimum competencies (compare with the similar curriculum response in the 1930s, Section 2.2.2.3). Other programmes avoided this extreme with a truly mathematical approach of emphasizing applications but also the necessary intellectual skills of creative problem-solving to deal with these applications and to prepare students for today's increasingly mathematical world. This latter curriculum emphasis demonstrates that mathematics education can learn from mistakes of the past while still retaining the very real gains which came out of the "modern mathematics" work.

Happily, in the opinion of the researcher, the new syllabus for teachers' college mathematics fits this more enlightened pattern, perhaps better than any of the other school mathematics syllabuses in Nigeria. The calculation and measurement skills, often only poorly learned in primary school, receive much emphasis, both as revision and in moving into higher levels. Intuitive geometry and general algebra are well covered without the worry of formal proofs or overly technical terminology. The topic of statistics prepares students for one of the more common ways in which they will encounter higher mathematics in their adult lives. Finally, these are all fitted together under a theme of practical problem-solving skills with specific coverage given to the simple logic of inference and reasoning and a general emphasis on making estimates and approximations, and checking the reasonableness of results.

2.2.11.2 National Policy on Education: Not only does this syllabus fit the prevailing patterns in mathematics education, but it also satisfies the guidelines of the National Policy on Education (1977, 1981). Since the four basic objectives, stated in Section 2.2.10.3, are intended generally for all areas of education, they are not expected to be equally applicable to mathematics education. However, in some ways, each can be related to coverage in the new syllabus. "National consciousness" is reflected in the very first section of the syllabus where students are encouraged to consider the counting systems of their home languages. "Attitudes for survival" certainly include the thinking and problem-solving skills which receive much prominence. The intuitive geometry covers the patterns and properties of the shapes of the natural and man-made world; this, and also the clarifications of data brought in statistical treatments, guide students to a better "understanding of the world around". Most directly, a mathematics programme of computation, problem-solving, and application most certainly can lead to the "acquisition of appropriate skills, abilities, and competences... as equipment for the individual to live in and contribute to the development of his society."

2.2.11.3 Teaching Methodology for UPE: Finally, and perhaps most important though previously not mentioned, the new mathematics syllabus for teachers' colleges helps with the major goal of all teachers' colleges: to train new teachers. One-sixth of the new syllabus - two-and-a-half out of fifteen terms - is devoted to primary mathematics methodology (see Section 3.5.4.3). There is much mathematical background of primary topics, and coverage on lesson organization, teaching aids, and evaluation of pupil performance. But more important, there is also emphasis on practice in communicating these ideas of relevant, useful and challenging mathematics, passing the ideas on to primary pupils.

2.2.11.4 Need for More Development and Implementation: The syllabus is ready and it seems quite appropriate for Nigeria's needs in basic mathematics for primary teacher education. However, the syllabus is not the end of curriculum development. It still needs (a) to be expanded into the form of textbooks or other teaching materials ready for classroom use; and (b) to be brought to the attention of the teachers so they will understand its content, approaches, and goals, and will be able and willing to use it in their classes. These two remaining steps are the focus of the present research; the series of workshops which are part of this research attempt, in a small way, to aid in accomplishing the implementation of the new Teacher Education Mathematics Curriculum.

2.2.12 Section Summary - Mathematics Curriculum Development

Organized planning of mathematic curricula was minimal prior to the 1890s, while much of the curriculum was arithmetic and other basic mathematics for everyday use. Several commissions made curriculum recommendations in the early years of this century. Although the commissions were mostly established by groups of mathematicians, several included classroom teachers as members, significantly the committee that prepared the "1923 Report" which anticipated much of the thinking of the mid-century curriculum revision movements. During the period of 1925 to 1945, concerns of psychology, efficiency, and economic depression limited the growth of mathematics curricula, but the demands generated by World War II and the growth of technology led to calls for much stronger programmes of school mathematics.

The resulting "modern mathematics" curriculum revision campaign was actually a large number of different programmes developed all over the world with a variety of goals, contents, and teaching methodologies, though generally aiming at greater student participation in the learning process and greater structural unity in the content. Many programmes tried to involve classroom teachers in planning, writing, and developing the curricula materials, but still one of the biggest problems of implementing the new programmes was teacher training. Teachers - especially those who were not mathematics specialists - needed to learn about the programmes' new content, to gain skill in the new teaching methods, and to become convinced of the tenets of the new objectives and philosophies.

In developing countries, including Nigeria, the problems of mathematics curriculum development and teacher familiarization were compounded by newly independent structures of government, rapidly expanding educational systems, the desire for greater cultural relevance of programmes, and serious shortages of qualified teachers. Although there was some effort to involve classroom teachers in the development of curricula, in many cases new programmes were introduced without adequate teacher preparation. The result often was poor teaching, and then poor results, which led to serious criticism of the new curricula.

In the early 1980s, Nigeria has new mathematics curricula for the different levels of schooling. The implementation effort again must not forget the individual teachers in the classrooms. The present research considers the implementation of the syllabus designed for mathematics in the teachers' colleges.

Can teachers become more familiar with the syllabus and also come to feel that they have been involved in part of its development? Will this make them more ready to accept it in their classrooms?

The answers to these questions partially must reflect the experience of the past decades of curriculum implementation. For the specific case under consideration here, the answers are sought by the experimental part of the present research. But also, the answers will be drawn from theoretical models and case studies discussed in the following section.

2.3 Curriculum Implementation

2.3.1 Growth of Curriculum Study

The 1960s was a time of much activity in curriculum development in all fields and in all parts of the world, especially through the means of organized curriculum projects. The Western and Communist blocs were in high competition for technological, economic, and political supremacy, and both considered the improvement of their school curricula as an essential element to strengthen their positions. The spurt of technological growth which had begun in World War II led to demands for much stronger programmes in school science and mathematics. Rebounding economies in Europe, America, Japan, and elsewhere provided funds for many projects of curriculum revision and improvement. The "baby boom" of population growth brought increased numbers of students into the schools and the need for innovative curricula to maintain quality in the face of greater quantity. Goodlad et al (1966) offers a clear and concise overview of the 1960s boom in curriculum development; also Miles (1964a, pp.2-10) mentions several of the causal factors, with supporting statistics and further references. In mathematics, Freudenthal (1978a) includes articles from sixteen countries, many of which make similar references to the factors leading to interest in curriculum change in the 1960s. Minority groups in Western countries and the rapidly expanding number of newly independent countries of the Third World began to call for new curricula especially oriented to their own needs and values (e.g., in Nigeria, Adaralegbe (1972), Fafunwa (1974)). All of these forces came together to support intense activity in curriculum development. Some of the mathematics programmes resulting from this activity are described in Section 2.2, but these represent only a small fraction of the work in mathematics curriculum, not to speak of similarly productive work in the sciences, social studies, humanities, and other areas.

Although curricular matters had been discussed long before the activity of the 1960s; e.g., in such classics as Bobbit (1918) and Tyler (1950), the boom in practical curriculum development work also led to considerable growth in academic interest in the problems of curriculum. An indication of this interest can be seen in two popular textbooks on curriculum studies, Orlosky and Smith (1978) and Short and Marconnit (1968), both of which are collections of a wide variety of readings on various aspects of curriculum studies, nearly all written after 1960. Many important curriculum textbooks - Taba (1962) and Doll (1964) to name only two - also first appeared in the early 1960s. In Britain, the Schools' Council for Curriculum and Examinations was established in 1964, with the objective of not only initiating and supporting new curricula developments, but also to study the process of curriculum development. Research from Schools' Council work abounds especially in British educational and curriculum research journals and in various publications of the Schools' Council itself. (Some of these studies which are particularly relevant to the current research; e.g.

Shipman (1974) and MacDonald and Walker (1976); are mentioned below: Sections 2.3.4.2, 2.3.4.3, 2.3.5.3, and 2.3.5.4). The fundamental processes of curriculum development became the subject of scholarly debate, especially the question of formalized and structured procedures as advocated by Tyler (1950) and Gagné (1967), versus a looser, deliberative, pragmatic approach as supported by Schwab (1969) and Walker (1971).

2.3.2 Diffusion of Educational Innovations

2.3.2.1 Sociology of Change: Increased study of curriculum soon led to academic consideration of curriculum change and the implementation of innovative curricula, just as increased practical work in design of curricula led educators to confront the very real problem of convincing schools - administrators, teachers, parents, students - to accept the products of the design work and to prepare all those involved to make the change as smooth as possible. The study of change and innovation has its roots in sociology, as the introduction and acceptance of any new idea involves many complex interactions of individuals and groups. The decade of the 1960s saw much work in this area, exemplified by such studies as Inkeles (1964); Bennis, Benne, and Chin (1969); and Gross, Giaquinta, and Bernstein (1971). They generally discussed the pressures and conflicts working for and against the introduction of new ideas and new techniques, and the role of individuals or groups as agents of change. Some of the research carried special meaning in the Third World countries in terms of studies of modernization in traditional societies. Herskovits (1964), Lloyd (1967), and Hunter (1969) are only a sample of the many studies in this area.

2.3.2.2 Rogers: Probably one of the most comprehensive early reviews of work in this area - the spread of new ideas - was by Rogers (1962). Rogers looks at studies of the change process - he calls it the "diffusion of innovation" - in his own field of rural sociology and compares the findings with studies of similar processes in industry, medicine, and other areas - including education. In all, he reviews over five hundred studies and develops generalizations leading toward a theory of innovation and innovators.

Rogers (1962) suggests that acceptance of innovations along a time scale follows a five-step pattern: (1) Awareness - knowing that the innovation exists; (2) Interest - paying attention to learn more about it; (3) Evaluation - deciding if the innovation merits further action; (4) Trial - temporarily accepting the innovation to test if its use should be continued; and (5) Adoption - accepting the new idea (or new product or new method) on a more or less permanent basis. This can be compared with the similar sequence described by Hoyle (1972) and mentioned in Section 1.5.4. The Awareness and Interest stages seem to both come under Hoyle's Dissemination; Interest and Evaluation together match Demonstration; Trial approximates the Implementation stage of Hoyle; and Adoption is nearly equivalent to Institutionalization (See also Section 2.3.4.4).

Also Rogers (1962) typifies acceptors of innovations according to their early or late acceptance, and found their numbers forming an approximate normal curve. "Innovators", two standard deviations ahead of the mean, are the first to accept new ideas, usually direct from the researchers. The next group, between one and two standard deviations before the mean, he calls "Early Adopters"; they are respected opinion leaders, learning of ideas from change agents. They are followed by the "Early Majority", within one standard deviation ahead of the mean, who also learn from change agents but deliberate longer and await results from their earlier peers. The "Late Majority", up to one standard deviation behind the mean, are sceptical, following their peers only with some pressure. The last, beyond a standard deviation behind the mean, are the traditionalist "Laggards". (Rogers (1962) pp.161-162)

2.3.2.3 Early Studies in Educational Change: Rogers (1962) devotes little space to innovation in education, largely because he found fewer studies in this area and little connection to other areas of diffusion studies. He points to Paul Mort as the earliest researcher to study the spread of educational innovation; e.g., Mort and Cornell (1941); and following Mort's conclusions, he reports a long time lag between the development of new ideas and their general acceptance for classroom use. One of the key factors in acceptance of change is seen to be cost. It should be noted that Rogers considers all types of educational innovations - in administration procedures, classroom organization, new educational technology, etc. - and does not particularly discuss change in curriculum. Rogers and Shoemaker (1971) did a follow-up study of the diffusion of new ideas, and considered the special problems of encouraging change in a cross-cultural setting. When the cultures of the innovator and the would-be adopter are different, the need for clear communication becomes even more crucial to the success of the innovation.

2.3.2.4 Miles and his Contributors: As Rogers (1962) pointed to the need for more study of educational change, he was pleased to note the then-forthcoming compilation of such studies, edited by Matthew Miles. Miles (1964b) did help to fill the gap of serious writing on the process of gaining acceptance of new ideas in education. The book is a collection of case studies, articles of research and theory, and studies of how various parts of the educational system affect the spread of innovations. Like Rogers, Miles considers a wide variety of innovations in education rather than focussing on changes in curriculum. However several of the articles in this collection offer findings quite relevant to the present study. The remainder of this section discusses some of them.

Eichholz and Rogers (1964) repeat some of the same points that Rogers (1962) make, though turned around to look at the rejection rather than the acceptance of new ideas. They again call for more cross-discipline studies of diffusion. Also, Mort whose work was mentioned in Rogers (1962), has a posthumous article. Mort (1964) reviews his long period of research in educational innovations and reiterates his earlier statements of the long delay (up to a century) between realization of a need for an innovation in education and widespread acceptance of the resulting new idea. To attempt to speed up the process, he says community support and professional leadership were found to be helpful, and further ease of acceptance comes if the associated materials are inexpensive and "all but self-teaching". (Mort (1964), p.319)

However, most of Mort's data were from the time before the big curriculum development "boom" and several of his findings are challenged elsewhere in the same book. Miles (1964a) himself points to the increased curriculum activity with references in various subject areas and geographical regions, and gives examples of changes progressing much faster than Mort would have predicted, in years or even months rather than decades. He points to affluence, technological growth, international competition, and quantitative growth of education as factors pushing faster innovation. But he warns that the process of implementing change remains poorly understood and that often poor strategies of implementation are employed in ignorance of the process. Hence, more study is required.

Carlson (1964) offers a sociological study of school superintendents who accept "modern mathematics" programmes. Some of his findings echo those of Rogers (1962) in terms of pointing to characteristics of early vs. late acceptors; his sample shows strong evidence of earlier acceptance by people who are highly interactive in the social network and have high prestige from levels of education, professional competence, and salary. Also, his data shows nearly universal acceptance of the new programme in less than ten years.

The chapter by Marsh (1964) also challenges Mort's older model with a report of the remarkably rapid spread of the new secondary physics programme of the Physical Science Study Committee (PSSC) (also mentioned in Section 2.2.8 for its link to Entebbe Mathematics). Only six years after the initial planning, the PSSC course was being used by about one-fifth of American secondary schools nationwide. Probably the main reason for its success, Marsh suggests, was the appeal it made directly to classroom teachers. A lack of communication between the designers and the school administrators, which Mort would have considered a fatal flaw in the implementation plans, was counteracted by good materials tested in real classrooms and revised according to teacher evaluations, and by a large programme of summer institutes for teacher familiarization and training.

Partially answering his own call for more theoretical study of the implementation process, Miles (1964a) at least offered a grid of cells in which to classify various problems, programmes, and research studies of educational innovations. He modified Rogers' (1962) five-stage sequence (2.3.2.2) by including an earlier step of Design of the innovation (since that is often linked to implementation), combining Awareness and Interest into one step, and dropping the final step of Adoption (since that is beyond the actual spread of innovations). Then he sorted innovations as those initiated *by the target group* who would be using them or those initiated *by others*. Finally each of these two categories was divided into those using *existing* structures and those creating *new* structures. To fit the situation being studied in the current work into this pattern, it (like those of other new curriculum projects) belongs in the group of *new* structures (a new syllabus and textbooks) initiated *outside* the target group (by committees of the Federal Ministry of Education). This study is mainly located in the Interest-Awareness and Evaluation stages. However, the study investigates greater participation of the target group (classroom teachers) even in the Design stage.

The final chapter of Miles (1964b) to be reviewed here is that by MacKenzie (1964), who also offers a model to guide the study of curricula change. He considers the internal and external participants in the change; the power and influence which they control and use; the phases in the process - from criticism of the original situation, through development, evaluation, and action on proposals for change, to implementation of action decisions; and the target - which he calls the "determiners of the curriculum". All is set in the cultural context which affects all the categories. Using MacKenzie's terms, this study intends to investigate greater participation of teachers in addition to the external participants; using greater communication, cooperation, and collaboration influences; for further development and clarification of curriculum change proposals.

2.3.3 Models of Educational Implementation

2.3.3.1 Chin and Downey: Rogers (1962) and Miles (1964a) had both urged educational researchers to make more detailed studies of the process of educational innovation, and by the early 1970s this call had been heeded.

The survey by Chin and Downey (1973) reviews some of the work in progress, noting the diversity of sources of research in this area and the difficulties of tying the data together into an organized discipline, but making an attempt to provide some theoretical and definitional structure to the field. They describe the study of planned, intentional change as initially drawing on the older work on change from the fields of sociology and psychology and on the understandings of how parts of a system fit together and how variables are correlated (This is similar to the comment in Section 2.3.2.1). They point out that the nature of planned change makes it "blur the usual distinctions between basic and applied knowledge" (Chin and Downey (1973) p.519) so that the practitioner may be the direct source of theory and theory may have immediate application.

Although grand overall theory in the field may be long in coming, work is needed to link empirical data into paradigms, models, and "middle-range" theory. As a start, there is a question of basic definitions: What is change? What is an innovation? Is the change to be defined in terms of the innovation itself, the system where the change takes place, or the processes of how the change comes about?

Changes in the physical sciences and even the life sciences are usually quite easily observed, but in social and behavioural sciences and especially in education, it is often hard to clearly state that a change has happened, that it has begun, or that it is in progress. Clearly more work and more attempts at models are necessary to understand such planned change.

2.3.3.2 Havelock: One of the most thorough studies of change processes in education is by Havelock (1971). He reviews four thousand studies and reports of educational change, and sorts them into three major models of implementation strategies: "problem-solving", "social interaction", and "research, development, and diffusion (RD & D)".

The problem-solving model centres attention on the group to receive the innovation. Sensing a need for change, the group (or part of it) initiates the process by stating the problem and searching for an innovative solution either from within the group or, more likely, from external sources. The receiver continues to control the situation through the development of the innovation and then brings it for implementation, modifying and adapting it as necessary. The significant characteristic of this model is that the receiver, in a client role, initiates and controls the innovation and hence, should be quite ready to accept the result.

The social interaction model begins with the awareness stage at the introduction of an innovation which has already been developed outside the receiving group. The model centres mostly on the spread of the new idea among individual receivers in the target group, much along the pattern described by Rogers (1962). Interaction of members of the target group and the relative positions of receivers within the social structure of the group determine much of the pattern and timing of the acceptance of the new idea. The amount of personal contact and clear communication are key factors for success of implementation.

The research, development, and diffusion (RD & D) model follows the process of innovation from the initial statement of the problem and early research; through the development of the innovative solution; and on to the introduction, trial, and acceptance of the new idea by the receiving group. It is like the problem-solving model in following through the steps prior to diffusion, but unlike the problem-solving model and like the social interaction model, it assumes research and development to be initiated and carried out by those outside the receiving group. This is the model most often followed by large, organized efforts at educational change, in particular by most big curriculum change projects. Generally, the model assumes changes resulting from expert - and often expensive - research work over a fairly long time-span. Acceptance by a usually large and passive receiving group is often expected to result from clear presentation of the reasonableness and quality of the innovation by the developers and change agents. The mathematics curriculum being studied in this research fits best into the RD & D model in that the design work was done by a group external to the users. However, in fact, the amount of research and development work assumed by the model is more than was done for this curriculum.

2.3.3.3 Schon: A rather different classification of implementation and diffusion efforts is by Schon (1971). He wrote not specifically of educational change, but educators (e.g., MacDonald and Walker (1976)) quickly saw the relevance of his model to the area of curriculum change. He also classified types of change into three categories, but based more on the structural pattern of the diffusion, rather than the process and roles of change agents and receivers.

Schon's first type is the "centre-periphery model". Here the innovation has already been developed and the task is for a central agency to spread the new idea out to the "periphery" of the potential users. The diffusion is organized and controlled by the central body. Success in this model depends on the organizational strength and amount of resources available in the "centre" and the quality of the infrastructure and communications reaching between the centre and the peripheral users. This pattern has often been seen in curriculum development projects, especially where a high-powered team (the centre) moves from development into the implementation, carrying their work more or less directly to the schools (the periphery).

Schon's second type, "proliferation of centres", is basically a two-step version of his first. A primary centre handles the diffusion of the innovation by coordinating diffusion from many secondary centres. The secondary centres actually spread the new ideas to the now greatly enlarged periphery, but function under greater or lesser control from the primary centre. Thus the primary centre diffuses not only the new idea, but also the methods of diffusion to be used, and hence becomes a "trainer of trainers". Schon's examples included industrial innovations and even the spread of Communism, but in the present context, examples might be the various programmes for training a selected group of teachers who are then expected to organize local workshops to train others - e.g., the cases of Sri Lanka and Philippines and the ABC Institutes of the Entebbe programme, mentioned in Sections 2.2.6 and 2.2.8. Like the first model, the strength of the primary centre is important to success. Close coordination of secondary centres can greatly expand the reach of the diffusion campaign, but there is also a risk of local pressures causing the secondary centres to break away from the central objectives. In this model, the communication called for in the "centre- periphery" model will not suffice; rather some degree of force is needed to coordinate the efforts to win the battle.

Schon's third model is labelled "shifting centres". Here the centres of new ideas rise and fall in influence, and the ideas themselves also change; all roughly follow a similar basic philosophy but are independent and flexible in terms of organizational structure. His example was the "counter-culture movement" of the late 1960s, advocating various policies of civil rights, antiwar, environmental protection, etc.; without any established centre, but with a rather successful diffusion of ideas through society. It is harder to find examples in education, partly due to the given administrative structures of education, but to some extent, the overall "modern mathematics" movement, especially in the United States, followed this pattern with many independent efforts with roughly similar goals. Perhaps in a age of rapid communication and easy transportation, ideas can spread faster and with less respect for boundaries and hierarchies. But also they can become outdated and discredited much faster, before even having a chance to become institutionalized. A similar point was made in terms of the basic directions of mathematics curriculum in Shirley (1980a). Previous history over the past two centuries seems to show gradual cyclic changes in mathematics curricula, but in recent years the cycles have speeded up so much that it becomes difficult to indicate the current point in the cycle.

2.3.3.4 Bhola (CLER): One remaining model that has received some attention is briefly discussed in Bhola (1977). This is the "configurational model", also referred to as "CLER", an acronym of the initials of its four main parts: configurations, linkages, environment, and resources. Configurations are the sixteen possible pairings of individual, group, institution, and culture, with each other in roles of innovator (change agent) and adopter (target). A study of a change is first determined by noting which configuration is basically involved. Linkages refers to administrative and communication connections between innovators and adopters, and possibly between others involved in the process. The links may be pre-existing or created especially for the change effort. Environment means all the external influences on the process - supportive, neutral, and inhibitive of the change. Resources include not only material and personnel, but also conceptual (e.g., the need for training in new content), influence and power, institutional stability, and time. Any innovator planning for change or any adopter contemplating the acceptance of a new idea can analyze his position and develop his strategy by careful study of the roles and interactions of all the relevant configurations, linkages, environmental forces, and resources.

This is more of a technique for innovation rather than an academic model. However, it may be considered an expanded example from Havelock's (1971) social interaction class of implementation types (Section 2.3.3.2), as it assumes previous research and development and begins with the diffusion of the resulting innovation. Applied to the present study, the CLER would put the basic configuration as that of an institution (the Federal Ministry of Education) as the innovator (since the new programme was called for and developed by agents of the Ministry), and the group of teachers in the schools as the adopters. The linkages include workshops, particularly the workshops organized as a part of this research project. The environment includes general public concern for the standards in school mathematics performance. and. the compulsion for change by the power of the Ministries of Education and the examination system, which, in different ways, are both supportive of change; and the inhibitive effects of the rapid expansion of the educational system and the shortage of qualified teachers. The considerations of resources include materials, in the form of availability of books; teacher training to build conceptual understanding of the new programme; time for trying out the material and becoming familiar with it; and much more.

2.3.3.5 Dalin: The many theoretical models described in the previous sections were all drawn from experience, and all attempted to guide understanding of the process of change in curriculum and education in general. But their very variety demonstrates again the point made by Chin and Downey (1973) (Section 2.3.3.1) on the difficulties in organizing, describing, or codifying this extremely complex process: Havelock (1971) (Section 2.3.3.2) follows through the sequence of acceptance; Schon (1971) (Section 2.3.3.3) looks at the organization of structures of diffusion; the CLER model (Bhola (1977)) (Section 2.3.3.4) emphasizes the role relationships and forces of environment and resources; and Carlson (1964) (Section 2.3.2.4) considered characteristics of the adopters. Dalin (1978) looks upon this confusing scene and says, in essence, that educational change is too complicated for any model. He feels that most models tend to ignore the confrontations and debates from ideological differences and the conflicting demands from the many different involved sectors of the educational and more general environment of the innovation. Promises for educational reform often fail to be fulfilled, partly due to the educator's failure to understand the process of change. As an example, he notes that in some areas, "modern mathematics" was rejected, not for any flaws in content, but because it was a foreign idea - a political problem probably not even considered by the curriculum developers. As is discussed in Section 2.2.10.4, "modern mathematics" met such a fate in Nigeria: its "foreignness" was part of its problem; a military decree to end it certainly was not expected by its developers. Often, innovators are only concerned about the content of a change and not the circumstances and situations where the change is to be carried out - nor even the objectives and potential benefits of the innovation. Howson (1978) (Section 2.2.5.4) and Vogeli (1976) make similar points, both considering "modern mathematics". Vogeli notes the validity - and even success - of the "premise" of "modern mathematics" even as the "process" failed to gain its acceptance.

Dalin (1978) calls for a more "process-oriented" view of innovation and offers a list of points that must be considered to understand educational change. The effects of the change - both intended and unintended - represent the objectives and the other, much harder to predict, results of the change. One also needs to ask who will benefit from the change, who will decide to make the change, and who has to change. These three groups may or may not overlap, and the seemingly obvious specification of the three groups may reveal crucial relationships affecting the success or failure of the implementation. An example relevant to the current study is that the teachers of a proposed new programme form the group who will actually have to make the biggest change, but they are often not taken into account by planners and developers of new curricula, nor even by those who make the decision to change, usually officers in ministries of education.

The characteristics of the change itself also vary widely and can affect the success of the implementation. Even the question of how to characterize the change is complicated; so much so that Dalin gives three different ways of classifying change. The first is by the area where the change happens - in functions, in organization, in role relations, or in curriculum. Then he looks at a categorization from a Rand Corporation study (Greenwood, Mann, and McLaughlin (1975)): centrality (does the change affect norms or patterns that are deemed basic or central to the institution?), complexity, nature and amount of change to be made by individuals involved, consonance between the goals of the innovation and the adopters, and visibility and observability of the change. (Chin and Downey (1972) (Section 2.3.3.1) reporting the work of Zaltman and Lin (1971).

list twenty "dimensions of an innovation" which include these same categories, plus factors of cost (in time, money, and risk), decision-making and commitment, communication, and others.) Dalin's third list seems easier to use for classification: labelling the change as technological, behavioural, organizational, or social.

Dalin (1978) feels that earlier writing on innovation tended to limit the difficulties of implementation to "resistance" by the expected adopters. He points to Rogers' (1962) categorization of adopters (Section 2.3.2.2) as an example. Rather, he argues that (a) this assumes that the innovation is always something "better" than the prevailing situation, and (b) the term "resistance" seems to neglect the complicated interplay of the forces of the social system. He prefers instead to focus on four "barriers to change": (1) value barriers from varying ideologies and beliefs; (2) power barriers against the redistribution of power that some changes bring; (3) practical barriers - poorly designed innovations, and management problems resulting in poor deployment of resources (including time, knowledge, incentives, material resources); and (4) psychological barriers of resistance, for reasons such as insecurity, even when the other barriers are minor or nonexistent.

Following a discussion of yet another set of factors in the web of educational change (the organizational structure of the school) and then a rather wide-ranging review of various models of social and economic change, Dalin concludes that no single model can adequately represent the complicated accumulation of forces affecting educational change. Still, noting the need for further research toward a "theory of educational change", he offers a framework to guide further study. Although his "framework" seems to resemble yet another model, he pointedly says it is not; instead it is a presentation of the basic factors and their relationships that need to be considered in an analysis of educational change. Much of his framework is drawn from the ideas that have just been discussed, so a brief summary should suffice to indicate his main points.

The framework consists of four major parts, all of which are mutually interacting. They are (1) the educational setting; (2) the environment; (3) the innovation; and (4) the change strategy. The educational setting includes financing and resource allocation, the decision-making structure, the support services, the size of the system, and the school level. The environmental factors are the more general influences - the economy, political stability, social expectations, and labour market, teacher unions, the relation of education and its role to other sectors of society (industry, agriculture, welfare, etc.), and change in technology. The characteristics of the innovation consist of three descriptive categorizations of innovations given above. Finally, the points to be considered in the change strategy are the norms and controls which regulate the change, the process and level of decision-making, and the linkages among the participants, agencies, and resources involved in the change. These many critical factors are all important in educational change, but beyond their individual significance is their dynamic interaction. With so many interlocked influences, it is very difficult to be sure of successful implementation.

Dalin (1978) notes that imposing innovations from above or from outside will often neglect many of the factors which are more internal to the system, but the value of external experience and expertise cannot be neglected either. "Successful implementation would mean the ability of the institution to be responsive to externally developed and/or directed innovations on the one hand, and at the same time the ability of the institution to develop a creative growth and improvement process ... a mutual adaptation and development process" (Dalin (1978) p.96).

2.3.4 Case Studies of Implementing Curriculum Change

2.3.4.1 Reid and Walker: Dalin (1978) (Section 2.3.3.5) had based his framework design on over one-hundred-and-fifty case studies of educational change in a wide variety of forms, sizes, and settings. He implied that such a case-study approach to this kind of research is the only way to see the many conflicting forces at work in their multifarious manifestations. Several recent studies specifically on curriculum change seem to follow the same case-study approach.

Reid and Walker (1975) collected six studies of curriculum change in Great Britain and the United States, ranging from changes in art instruction to the diffusion of Keynesian macro-economics through textbooks. Their concluding chapter offers some valuable reflections on curriculum change - and, significantly, on curriculum stability. Curriculum design often seems more concerned with rational processes, specification of precise objectives, and fitting new curricula into the evaluative designs of psychometricians, than with the realities of the classroom and the actual conflicting forces that act on curricula in practice. Theories of curriculum implementation also at times seem neglectful of real-life problems, but the nature of implementation forces its theories closer to pragmatic concerns.

Curriculum design needs to come closer to curriculum implementation and the interconnected pair needs to take more cognizance of the forces and demands of the school situation.

Among the realities that are especially relevant to those who would bring change are the forces of curriculum stability - "the values, beliefs, and expectations of teachers. they way classrooms are organised, and the nature and availability of outside support". (Reid and Walker (1975) p.248) Like Dalin, Reid and Walker do not like the term "resistance", and they do not believe that over-specified, unchanging objectives should be the pattern of curricula. Instead, they call for more reliance on the teachers' experience, more curriculum negotiation and deliberation, and (following the emphasis of Schwab (1969)), more concern with the "practical".

2.3.4.2 MacDonald and Walker: MacDonald and Walker (1976) (note that this is Rob Walker, not Decker Walker of the previous section) also base their conclusions on case studies, especially three British projects in geography, science, and technical education. They begin with a good summary of theoretical models and a historical sketch of curriculum change in Britain between 1960 and 1975. Like Dalin (1978)

(Section 2.3.3.5) and Reid and Walker (1975) (Section 2.3.4.1), they find the theories oversimplified. They draw especial attention to forces of internal and external politics, individual goals and ambitions, and the often tenuous organizational support of curriculum projects. These factors appear to them to be much more important in implementation than the merits of the programme's content or even the stated strategies of dissemination.

One apparent "failure" of much curriculum implementation which is often mentioned (e.g., Gallagher (1967), Goodlad (1967), Davis (1971), and Howson (1978)) is that the ideas of curriculum developers are modified considerably by the time the curriculum reaches the students. Often this is blamed on poor explanations offered by the designers in training the teachers and on general lack of communication. However, MacDonald and Walker (1976) argue, with supporting examples, that this "gap" in interpretation of the programme comes from the negotiation process used by the developers. Knowing that academic critics have one set of expectations for a curriculum project and the adopting teachers have a different set, the designers adjust their explanations of the project accordingly when their audience is theoretical academicians or practicing teachers. For example, university researchers might hear of a project's well-designed pedagogy and reliance on the latest developments in the content area, while school teachers would be told that their own classroom autonomy was to be respected, which their training in content would reflect their own interests and ability. Thus, when implementation is discussed, the question might not be whether the curriculum is implemented, but which curriculum is implemented. There may, in fact, be many versions of the project's output.

The varying descriptions given by project designers may actually reflect their lack of security, trying to satisfy the different audiences. Instead of the image of a powerful project usurping the powers of the schools by decreeing a new curriculum, MacDonald and Walker instead describe the British curriculum projects as small organizations with shaky support, buffeted by the powerful forces of politics and economics, and the established positions and powers of the various segments of education. Hence, implementation becomes much more difficult to describe and success in implementation much harder to define.

2.3.4.3 Shipman: In a much more intensive case study, Shipman (1974), reaches similar conclusions. Shipman sat in on much of the work of the Keele Integrated Studies Project, mostly as an observer, and also interviewed many other participants, mainly teachers, principals, and education authority officials, to derive a sociological picture of a curriculum project in action. The main objectives of the Keele Project were to provide materials, training, and other support to schools for the establishment of programmes of integrated studies in the humanities, and to encourage the use of team-teaching for the relevant subject-area teachers to carry out the integration. The innovation - involving many subject areas and the breaking down of their discipline boundaries as well as a difficult change of role for teachers from autonomy to teamwork - is clearly a more complex change than many; and, in particular, much more complicated than the fairly straightforward change of syllabus in one subject which is investigated in the current research. However. Shipman's involved study brought out many points relevant to any research on curriculum change.

Shipman (1974) made several recommendations to strengthen the process of curriculum implementation. He especially called for a better infrastructure to make stronger links between national and local agencies. Such organization could make for smoother coordination of work: between levels of the system, and over time - through the life of a project and beyond. A big part of this would be more in-service training programmes and an expansion of teacher centres, and generally, any efforts to bring teachers, administrators, and developers closer together.

Like MacDonald and Walker (1976), Shipman (1974) notices the variation in definitions and interpretations of key ideas in a project, though he does not imply the almost intentional variations that MacDonald and Walker describe. He does offer several reasons for the varying interpretations and the resulting difficulty in measuring implementation. At the very centre, the source of the innovation, the project team, he found a "fuzziness" of definition, partly due to the lack of time for the discussions which might have evolved a coherent idea. When the project reaches out to the local education authorities and the teachers, the different groups have different hopes for what the project will bring and hence different views of the project itself. As the project ideas diffuse still further, to new people not involved in the initial planning or the original training and lacking the enthusiasm of " "pioneers", there is a certain "dilution" of their meaning. The difficulty of staff mobility in the project team and among the teachers adds to this kind of variation as new people have to be rapidly briefed and brought into the team without the advantages of the deliberation that may have gone into the others' thinking. One variation was good teaching, but bad for the implementation: creative teachers made their own modifications on the project material - perhaps improving it, but taking it farther away from the initial definitions. Shipman (1974) refers to the "catalytic effects of projects /which may be more/ important, rather than the more limited impact of their specific curriculum objectives" (Shipman (1974) p.126). But this makes implementation more difficult to measure. Finally, and perhaps most important, is the problem of communication between the project and the teachers, which is discussed in Section 2.3.5.5, along with other problems related to the role of teachers in curriculum implementation.

2.3.4.4. Fullan and Pomfret: One of the most comprehensive reviews of implementation case studies, especially from the point of view of research methodology in the study of educational implementation, is by Fullan and Pomfret (1975). They consider twenty-seven American, Canadian, and British studies, pointing out problems in the field, and especially noting the techniques used for gathering, analysing, and reporting data on implementation. In three areas, the review is especially helpful: (1) It offers a good critique on methodology, both for actual implementation efforts in practice, and for academic study of such efforts. (2) It suggests areas where previous work is nonexistent or weak; areas where further research is needed. (3) It provides examples of techniques and findings of the reviewed studies, some of which are mentioned elsewhere in the present study in developing methodology, supporting some of the assumptions, and justifying the research. The major drawback of Fullan and Pomfret for this research is that they direct their focus more on the actual use of new materials and methods in the classroom, which is one or two steps farther along in the implementation process than the case being studied here. In that sense, Fullan and Pomfret may be even more useful for a follow-up study of this research a few years hence.

While MacDonald and Walker (1976) and Shipman (1974) were concerned about variations in key definitions within the process of implementation, Fullan and Pomfret (1975) also note a problem of definitional inadequacy in research about implementation. Most of the studies reviewed attempt to make some measure of the degree of implementation, but they do not agree on the meaning of "implementation". This same problem is mentioned in Section 1.5.4 of the present study where the important terms are defined and discussed. The problem is also noted in the comparison of the terminologies of Rogers (1962), Hoyle (1972), and Miles (1964) (Section 2.3.2.2); and Chin and Downey (1973) consider definitional problems at a more fundamental level - even to defining "change" (Section 2.3.3.1). Fullan and Pomfret prefer to use "adoption" for the decision to use a new curriculum, and to reserve "implementation" to mean the time when the innovation is in actual, regular use; i.e., after adoption. See Table 2.1. Unfortunately, this "adoption, then implementation" pattern is roughly the reverse of the use of the terms

Table 2.1

Comparison of Terminologies of
Steps of Implementation

Hoyle	Rogers	Miles	Fullan-Pomfret
Research Development	—	Design	—
Diffusion:			
Dissemination	Awareness Interest	Awareness-Interest	—
Demonstration			
	Evaluation	Evaluation	
Implementation	Trial	Trial	Adoption
Institutionalization	Adoption	—	Implementation

Sources: Hoyle: Shipman (1974) pp.159-168
Rogers: Rogers (1962) pp.81-86
Miles: Miles (1964) p.21
Fullan-Pomfret: Fullan and Pomfret (1975) p.11, ff.

by Rogers and Hoyle, so even with Fullan and Pomfret's explication of the definitional problem, they did not conclusively solve it. Also, as noted, their definition of "implementation" directs their study to a point farther along in the process than the current study considers.

However, Fullan and Pomfret do give useful warning of additional problems in measuring implementation. They ask for specific clarification to distinguish between (a) a decision to use a new programme, (b) the reported use of the innovation, and (c) the actual, observable, use. They point out that self-reports on usage from teachers may not be reliable, and reports from principals or supervisors may be even less reliable, due partly to assumptions about how they are expected to report. They also note that attitudes "are related to implementation, but they are not implementation per se" (Fullan and Pomfret (1975) p.24). The direction of causality between favourable attitudes and successful implementation may go in either direction. Thus favourable attitude measurements in this present study may imply future successful implementation (This could be checked in future research) or they may indicate that, at least so far, implementation is going well (although implementation in Fullan and Pomfret's sense is yet to begin here).

Another variable of the current study - participation of the teachers in curriculum development - received prominent treatment in Fullan and Pomfret (1975). They recognize four dimensions to participation - timing (when do users become involved?), the types of decisions the users are involved in, the degree of participation (their authority in making decisions), and the density of participation (the proportion of users involved). The first three of these dimensions are roughly reflected in Section B of the instrument of this study (Appendix D) while the response will give some indication of the fourth. Also, they report on six studies (Lamont (1964), Krey (1968), Poll (1970), Duet (1972), Hestand (1973), and Miller and Dhand (1973)) related to participation in curriculum development and subsequent implementation. All reported participation as positively linked to implementation (or at least to satisfactory adoption, in the case of Miller and Dhand). Duet showed that actual work on designing materials helped more than simply service on planning committees; Lamont demonstrated participation as leading to higher quality of use even when the quantitative measure of implementation was not influenced by participation; Poll found primary teachers more willing to plan and participate in curriculum design than secondary-level teachers. However, none of the six measured degree of implementation to the satisfaction of Fullan and Pomfret.

Based on these and other studies in their review, Fullan and Pomfret (1975) derive a two-way classification of participation patterns. The "managerial" pattern assumes a fairly explicitly defined innovation; the participatory role of the users-to-be is largely to be trained to handle the new curriculum and to provide feedback on their problems in using it. The "user" pattern puts the users-to-be in roles of greater authority to make decisions about the new curriculum and to evaluate, revise, and adapt it as they feel necessary; this requires less explicitness in the innovation's definition. Due to lack of empirical data, Fullan and Pomfret avoid saying which pattern is best for effective implementation, but they suggest that, because of the apparent difficulty in explicitly defining most innovations and their own value positions, they lean toward the greater decision-making participation by users.

2.3.5 The Role of Teachers in Curriculum Implementation

2.3.5.1 Monell: The role of teachers, in terms of participation, discussed in some detail by Fullan and Pomfret (1975) (Section 2.3.4.4), also features in several other studies, some of which are also discussed elsewhere in other contexts.

Monell (1979) reviewed professional literature to derive a list of eleven "critical elements" which affect the success of mathematics projects and then tested her list on ten successful and unsuccessful mathematics projects in California. Four of her eleven critical elements directly included participation of teachers in the change process: identified need (teachers helped assess needs); development of a plan for the projects (teachers were involved); participation (by teachers) in decision-making; and staff development. Several other factors (such as teaching materials, time, etc.) also were related less directly to teacher participation. All eleven "critical elements" were found to be more prominent in successful projects than unsuccessful projects.

2.3.5.2 Hansen: Hansen (1975) attempted to show relationships between several teacher-related factors involved in planned change. Although they were not statistically significant, he does find trends linking teachers' dispositions toward change and both their feelings of involvement in the change and their awareness of the innovations. These are similar to the measurements in the present study of attitude in comparison with measures of participation and knowledge of the new curriculum (See Sections 1.2, 3.2, and others). However, Hansen's study is more on institutional and administrative change than change of curriculum.

2.3.5.3 MacDonald and Walker: From a negative angle, MacDonald and Walker (1976) noted that some, especially early, curriculum projects attempted to by-pass the teacher altogether, not only in design and implementation of the programme, but even in its instruction; i.e., "teacher-proof" curricula. However, most such projects found out "that not even the most carefully designed materials are 'user-proof' in the sense that they clearly carry their own implications and are impervious to individual differences in the skills and attitudes of teachers who use them". (Becher (1971), quoted in MacDonald and Walker (1976) p.99).

2.3.5.4 Miles: The role of the teacher's autonomy and individuality also interests Miles (1964c). In his concluding chapter, he points to the confusion between this autonomy and the teacher's role as a part of the school's bureaucratic system. The latter role causes the teacher to follow texts and officially-prescribed syllabuses and may make him hesitate to initiate his own innovations. But his independence in his own classroom may make him resist ideas imposed on him from outside or above. Later Dalin (1975) notes that many other factors besides psychological resistance are involved, but still the feeling of outside interference with the teacher's own jurisdiction remains a problem for disseminating innovations.

2.3.5.5 Shipman: Shipman's (1974) study (Section 2.3.4.3) goes into considerably more detail on the feelings of teachers encountering a new curriculum. He finds the demands on their time and energy were considerable and were an important part of their response. There was much work in preparation of new content and new teaching approaches, and also they found they often had to rewrite the material as they found it aimed above the level of their students (MacDonald and Walker (1976) also note that the academic view of curriculum usually has "a high estimate of the ability of the low-achieving pupil" while teachers claim a "'realistic' view of the limitations of the pupil" (MacDonald and Walker (1976) pp.49, 50).). Also teachers had to make various arrangements for timetable and classroom adjustments, availability of materials, etc. On top of this load, the curriculum developers asked for their attendance at planning and training sessions and gave them forms to fill for evaluation and feedback.

Partially this workload was a cause for the serious communication gap Shipman (1974) detects between teachers and developers. Developers are very desirous of teacher input and feedback, but tired teachers do not see much value in completing forms and questionnaires (This problem also appears in the data collection for the present study; Section 5.3.2.3). Shipman feels that the failure to establish and use more teacher centres (as the plans had envisaged) greatly hindered the flow of communication and he points to the valuable service that is provided by teacher centres in some areas.

One other problem of communication was the status position of the developers vis-à-vis the teachers. The developers (mostly former teachers themselves) worked out of their base at the university. The teachers sometimes felt proud to be a part of a prestigious university-based project. But often they felt that "those university people" were either talking down to them or throwing around academic jargon based more on theory than their (the teacher's) sense of practicality. Somewhat in support of the teachers' viewpoint, Shipman seems to imply that some of the jargon covered over the developers' own insecurity, while, more in support of the developers now, he says that some was an honest attempt to explain the "why" of the project along with the "how".

2.3.5.6 Griffiths: The same issue of language is emphasized by Griffiths (1980). He notes that teachers often must adopt a language level midway between the theoretical language of research mathematicians and the everyday language of their students, translating abstractions into relevant applications. In much the same way, the language of educational theory and curriculum studies needs to be adapted toward the language of the man-in-the-street to explain curricular developments to parents, administrators, and the general public. Perhaps yet another language is needed for the teachers. Griffiths, like Shipman and many others, calls for many more opportunities to reach on-the-job teachers, since they will lead activities for change. He praises the teachers centres, the French IREM, and the Dutch IOWC (Sections 2.2.5.2, 2.2.6.2, and others), and says that this organization of continuing teacher contacts is the real job for curriculum implementation.

2.3.6 Studies of Curriculum Implementation in Africa

2.3.6.1 Sources: All of the research literature references mentioned up to this point in Section 2.3 are useful in providing examples, justifications, and theory for this research. However, none of them use cases from Africa nor consider the special problems of curriculum development and implementation in Nigeria, other African countries, or lesser developed countries in general. Partly, this is due to the difficulties of collecting information about recent research in Africa or even within Nigeria. Dissertation Abstracts International rarely lists research from African universities and no similar catalogue was found to meet this need. Within Nigeria, the Nigeria Educational Research Council has begun an attempt to prepare such a catalogue of educational research, but it is not yet available (1983). As this study neared completion, a bibliography of mathematics education in Nigeria (Adeniran et al, (1983)) was completed. It offered this researcher some last-minute assistance in tracking down references. However, unfortunately, proximity to the site of the research and chance play major roles in learning of other similar or related studies.

A second reason for the difficulties of finding related research in Africa is that very little has been done. Some of the reasons - mainly shortage of researchers and concentration more on curriculum development than implementation - are mentioned in Section 1.4.4. Many of the relevant writings that are available are reports of contents, designs, and plans for new curricula, many of which are mentioned in the historical review (Sections 2.2.8 to 2.2.11). It is more difficult to find studies of the implementation process or of the role of teachers in curriculum implementation - in mathematics or in other subject areas.

2.3.6.2 Hawes: The most useful general study that was found was Hawes (1979). Better than most studies, Hawes attempts to push past the rhetoric and official reports to get at "the reality" of curriculum development problems in Africa. He includes an objective overview of the Entebbe Mathematics (Section 2.2.8). Also, he gives good summaries of the contents of subject-area curricula and the actual curricula and instruction he observed in classrooms all over the African continent.

Closer to the theme of the present study is his critical discussion of various administrative arrangements for new curriculum design and some of the projects that have been undertaken. He notes problems of staff shortages and lack of sufficient funding, and the contradictory needs of curriculum-design units to be both autonomous enough for flexibility and yet tied to the decision-making, planning, and funding areas of Ministries of Education. In the projects that he discusses, he points to problems such as overextension - in terms of available staff, resources, and time; and also to successes of building closer links between primary schools and their local communities. (In a more recent article, Hawes (1983a) keeps his pragmatic point of view in discussing problems of implementing universal primary education programmes.)

Even closer to the present study is Hawes' discussion of curriculum implementation policies and practices. He describes several examples of implementation through various in-service schemes and revised pre-service training programmes. Throughout, he re-emphasizes the need for closer articulation and better communication between the classrooms and the trainers, and especially encourages the plans of using visiting advisors (who do not have inspecting responsibilities) who can regularly assist teachers with new curricula directly in the schools. The underlying issues are that everyone involved should feel involved, that the hard work of starting new curricula should be appropriately rewarded, and that the momentum of change and continuous development needs to be maintained.

If this brief summary of Hawes (1979) makes it sound less than "realistic", that is the fault of attempting to summarize. For every statement of idealistic policy or "how it should be", Hawes has many achieveable recommendations and anecdotes of "how it is". While reading Hawes, this writer kept finding himself nodding his head and saying, "Yes, that is exactly what I have seen; that is exactly where the problem lies". Several of Hawes' specific comments are considered more directly in the results of this current research and the emerging recommendations.

2.3.6.3 General African Examples: Several research reports on education include relevant studies from Africa. Thomas, et al (1968) has thirteen case studies, including one from Zambia and one from Nigeria. However, contrary to the title of the book - Strategies for Curriculum Change - both of these describe changes which seem more in the area of administration and structure. Jolly (1969) has nineteen articles on various issues and programmes in education in different parts of the continent. There is a section on curriculum, but mostly the articles give background for curriculum planning and some description of programmes.

The focus is much more on innovations and their implementation in Ponsioen (1972) which contains twenty-one articles, mostly case studies with some theoretical papers, on various innovations. The article most closely related to the present study is Dyaşi (1972) which describes the Science Education Programme in Africa (SEPA), a secondary science programme organized by the same Educational Development Corporation which sponsored Entebbe Mathematics (Section 2.2.8.2). Dyasi reports a flexible definition of the curriculum to help it fit into a variety of local situations, with teachers participating by supplying feedback on trial versions of the material. Also, Science Curriculum Development Centres (SCDC) in several countries coordinated the introduction and evaluation of the programme units and pre-service and in-service training.

Quinlan (1972) studies the relationship between changes in the secondary English syllabus in Kenya and the training of teachers. He points to the need for local involvement in curriculum change and for considerable training of teachers. He recommends that teachers' colleges should take an active role in curriculum development to help carry out both the training and local involvement. Also he notes that the cost of such development and training need not be high if proper planning is done.

2.3.6.4 Sierra Leone: Morris (1969) generally discusses curriculum change in Sierra Leone. Morris had, on his own, introduced the Joint Schools Project Mathematics (JSP) (Section 2.2.9.1) in the secondary school where he taught, and mostly discusses reasons for the change and his own experience. A. Williams (1978) looks briefly over twenty years of mathematics curriculum change in Sierra Leone and notes the in-fighting between advocates of different programmes with similar objectives. Also, he describes the use of writing workshops and some work in teacher-training. The present writer served as a Modern Mathematics Advisor in Sierra Leone, participating in an implementation campaign. Some observations were preserved in personal notes and in official reports (Shirley (1971, 1972)). Some of the factors which seemed important to the implementation process were: (a) the awareness on the part of principals and teachers of the proposed changes and their implications; (b) the familiarity of officials and developers with classroom problems; (c) the availability of materials; (d) personal and internal political relationships; and (e) the geographic and demographic size of the area where the change was happening. The first three factors stated negatively, and the fourth, all hindered the introduction of "modern mathematics", while the fifth - the small size of Sierra Leone - seemed to help the changeover. This experience is described in an unpublished seminar paper, (Shirley (1978)), and was part of the inspiration of the current study.

2.3.6.5 Ghana: Three dissertations were found describing curriculum change in Ghana. Brooks (1974) analyzes new primary science programmes and finds many varied implementation problems: lack of clear goals, national political problems, lack of incentives for teachers to change to new programmes, and the most serious: inadequate pre- and in-service teacher education, which implies insufficient numbers of teachers competent to handle the new programmes.

Awuku (1975) is more generally concerned with improving science education and making it relevant to the context of Ghana, rather than the introduction of any particular curriculum. However, he also emphasized the crucial role of classroom science teachers and the need for continual training.

Dotse (1977) also finds the lack of qualified teachers to be a major problem in a curriculum change in geography.

Although the Joint Schools Project (JSP) (Section 2.2.9.1) began in Ghana and seemed to spread rather smoothly, no research other than the rather descriptive reports mentioned earlier could be found. In fact, no research on any aspect of implementation of mathematics curricula in Ghana was discovered.

2.3.7 Studies from Nigeria

2.3.7.1 Science Education: Related research from Nigeria includes five recent theses on science curricula (Oyedum (1980), Brown (1978), Shuaibu (1979), Mani (1981), and B. Young, (1975)).

Oyedum (1980) is concerned mainly with curriculum trends in science, especially in Britain and the United States and their reflection in Nigerian science education. However, he calls for stronger infrastructure in Nigeria to aid curriculum diffusion, in the form of teacher resource centres and a clearinghouse of curriculum research and development.

Brown (1978) evaluates a primary science programme and finds that in many schools it was only partially (or poorly) implemented or not implemented at all, due mainly to the lack of appropriate materials and the need for more training of the primary teachers.

Shuaibu (1979) and Mani (1981) both compare the stated objectives and actual operation of school science curricula, and both report considerable discrepancies. They point out that teachers usually know and agree with the objectives, but their classroom behaviour does not show this understanding. Shuaibu suggests that new curriculum designs should reflect the demonstrated abilities of teachers, and that pre- and in-service training should emphasize various approaches and various teacher skills rather than demanding one particular methodology.

2.3.7.2 B. Young: The most relevant of these Nigerian science curriculum studies to the direction of the present study is B. Young (1975). Young worked as a science consultant on the same primary science project that Brown (1978) laters evaluates, the Primary Education Improvement Project (PEIP), science section. (Hawes (1979); Section 2.3.6.2) also discusses this project in general, and Kolawole (1980) offers an overview report on the entire project between 1968 and 1978, with discussion of its objectives and problems.) Young's dissertation amounts to an on-the-job analysis of the practical difficulties of implementing the project, often comparing his problems with those reported from Britain by Shipman (1974) (Sections 2.3.4.3 and 2.3.5.5). The project's main mechanism for implementation was a group of Mobile Teacher Trainers (MTTs), who were each assigned to a small number of schools, with the task of visiting the teachers, providing support in the form of on-the-spot training and advice, assisting with the distribution and use of special materials, and bringing in feedback from the teachers to the central curriculum developers.

At the time of Young's writing, the programme had begun well, under UNESCO/UNICEF support, but also had developed many problems which were expected to be exacerbated as the

UNESCO/UNICEF support was phased out. He notes particular concerns about money, manpower, and time; along with the structural problem of centralization of the project development, and the need to assume (and plan for) expansion of the project from its trial stage to a much wider attempt at implementation. The project had often been hampered by unplanned (and hence unbudgeted) expenses and difficulties of putting money where it was needed most. The costs of training, supplies, and the MTT work had been underestimated especially considering the planned expansion of the programme to many schools.

The problems of manpower were felt throughout the programme from shortage of subject-area specialists to the need for more skilled typists and drivers. Manpower shortage led to communication problems, staff turnover, and constant failure to meet deadlines. The time factor was tied in with manpower shortages but also related to competing demands for rapid production of materials and for more care in developing the teacher training and re-training.

B. Young (1975) points to the teacher as the focus of curriculum change, noting the successes as well as the problems in this area for his project. In primary schools especially, there are many problems of poor facilities, overcrowded classrooms, and the teacher's lack of training. However, Young praises the teachers involved with the programme, and especially the work of the MTTs, in getting the materials into use and providing feedback to the developers, especially given the often difficult conditions of work. But, as noted before, he is concerned about how the programme can continue its close contacts with the teachers under its proposed expansion. He hopes more curriculum centres can provide new foci for teacher assistance as this expansion takes place.

2.3.7.3 In-Service Training: Several recent studies on in-service training in Nigeria were found, including Osibodu (1975), Mereni (1976), Alhassan *et al* (1976), and Uche (1980).

The first, Osibodu (1975), a doctoral dissertation, surveys the provision of in-service training in mathematics for primary teachers in the former Western State of Nigeria and offers a model for a more systematic in-service programme. The second, Mereni (1976), also a dissertation, points out that in-service training, which he also refers to as "professional renewal", should not be considered as remedial work, but as a fringe benefit for professional development. Government should support such programmes as a continuing investment for better education.

Alhassan et al (1976) is the report of an undergraduate project of organizing an in-service workshop on mathematics for primary teachers in the Zaria area, and includes recommendations for the organization of similar workshops.

The last, Uche (1980) a journal article, summarizes reactions of teachers in Lagos State to in-service courses, again with recommendations for improvements.

All offer practical suggestions - on timing, participation, overnight accommodation, etc. - as well as more theoretical justifications and values of such programmes. All agree that careful planning and coordination are crucial to success.

2.3.7.4 Mathematics Education: Mathematics curricula in Nigeria have attracted some scholarly studies, but generally the ones that were found concentrated on aspects other than problems of implementation. Lassa (1975) and Ojo (1978) both looked at mathematics programmes in Kaduna State, one of the states included in the sample of the present study, but the former measured students attitude and achievement and the latter compared demographic data and attitudes toward mathematics.

Similarly, several of the studies mentioned in Section 2.2, the historical review, also discuss changes in the mathematics curriculum; e.g., Ohuche (1978) and Nwagwu (1981). Also the controversy over "traditional" and "modern" mathematics (Section 2.2.10.4) generated a variety of studies, e.g., Adeola (1972), Isiquzo (1977), Junaid (1975), Lassa (1973), Malumi and Ulemu (1977), Okuboyejo (1975), Olarewaju (1977), and Sale (1978). With the exception of Lassa (1973), which is a Master's thesis, all of these are undergraduate work, and all summarize the developments of that time, usually in terms of comparing the merits and demerits of the syllabuses. But while many of them mention such problems as inadequate teacher training and lack of materials, their main purposes are to describe the situation and summarize the developments in historical or comparative terms.

G. Williams (1974) is also referred to earlier (Section 2.2.8.1 and 2.2.8.2) in the discussion on Entebbe Mathematics and its offshoots. Williams directed the Lagos Modern Mathematics Project, a programme based on primary Entebbe materials. Besides describing the programme, Williams (1974) also discusses its remarkably successful implementation. The programme

> had all the necessary ingredients to produce a change - the existence of a Ministry that was convinced that the change to Modern Mathematics was necessary and desirable,... the personnel to initiate the change, texts and other materials and a carefully directed plan for the desired change spanning several years preparing the broad base and support necessary for the acceptance of the change. (G. Williams (1974) p.243)

No one had objected - hardly anyone even noticed - the start of the experiment in a few streams of Class One. Then with support from the overall African Mathematics Programme, there was much training given to participating teachers, retraining them in attitude as well as mathematics content. With these well-prepared teachers in the experimental classrooms, the pupils' achievement was markedly above their non-project schoolmates by Class Three or Class Four. This led to a demand among parents and headmasters calling for expansion of the programme. As more teachers became experienced with the programme, they formed a pool from which writers were drawn to prepare the statewide mathematics syllabus, and eventually the experimental work was taken as the basis of the official state programme. The report of G. Williams (1974) in mathematics education, along with B. Young's (1975) study in science education, come closest to the theme and location of the present study. Though neither offers empirical data, both point to the value of early teacher participation in curriculum development as a way of designing better curricula and a route to easier implementation.

However, even with an apparently smooth and successful implementation, the LMMP would later suffer from Nigeria's 1977 ban on "modern mathematics". Although everything seemed to fit together for success of the LMMP as of 1974, when G. Williams wrote her article, her closing sentence has a premonitory ring: "Several years of hard work is still necessary before we can truly claim that modern mathematics has come to stay." (G. Williams (1974), p.253)

2.3.8 Section Summary - Curriculum Implementation

Increased academic study of curriculum development followed closely behind the widespread development of new curricula in the 1960s. As the problems of implementing these curricula became apparent, increased emphasis was placed on studies of the spread of educational innovations and the process of curriculum implementation.

The earlier general model of diffusion of innovations led to a variety of models for the introduction of educational innovations. Some of the models traced the steps of the process of implementation; some considered the people and agencies involved; some looked at the organizational pattern and hierarchies of the implementation; and some discussed interrelationships, resources, timing, etc.

This confusing scene of a complex models led some to argue that there are so many forces at work - in the curriculum itself, among the people involved, within the schools, in the wider political and socio-economic environment, and in the details of the strategies for change - that any model is bound to be incomplete or even misleading. Rather, keeping these many forces in mind, more might be learned from case studies. Each new case may require its own explanation even as its participants learn from the experiences of others.

Several case study reports emphasize the need to consider the "realities" of the school situation; to follow practical, pragmatic approaches; and to consider the strong pre-existing forces of ambition, control of resources, organizational inertia, and structure of power. These may be more important to successful implementation than the quality of the curricula or any idealized implementation strategies.

Good understanding of the programme's content, methodology, and goals by all involved and clear communication among all groups are crucial. This includes better infrastructure for liaison, especially as the project reaches farther out of its source; more in-service training and practice; and more opportunities and places to bring teachers, administrators, and developers together for mutual exchange of ideas and concerns.

A major part of the recommended opening of channels of communication is an increased role for individual teachers, not only in additional training and familiarization (though that remains very important), but also in earlier opportunities for teacher input and participation in curriculum design and development.

There are problems associated with greater teacher involvement - the teachers' already-heavy workload, their sense of classroom autonomy, and their status in comparison with academic experts. However, the advantages of the teachers' fresh-from-the-classroom experience and, later, the increased readiness of the teachers to support the new programme make teacher participation very important.

Most of these reports were from outside of Africa as research from Africa is scanty and difficult to locate. However, some studies, such as reports of the Primary Education Improvement Project and the Lagos Modern Mathematics Project, seem to support both the pragmatic emphasis on remembering the realities of the situation and the need to make special efforts to reach out for greater teacher involvement and familiarization in the development and implementation of new curricula.

2.4 Other Literature

2.4.1 Sources of Information

In addition to the reports of developments in mathematics curricula and the studies of curriculum implementation, there are several references which provide general guidance in organizing the present study and offer specific suggestions in certain aspects of research technique.

Much of the research literature was gathered by the researcher in the normal course of his work and from general familiarity with local library materials and newly published books. However, specific searches were made in recent volumes of *Dissertations Abstracts International* (DAI) and DAI off-prints, *Doctoral Dissertations on West and Central Africa* (1980), *Doctoral Dissertations on East Africa* (1981), and *Current Research in Mathematics Education* (1982). Another bibliographic source was the *Journal of Research in Mathematics Education* (1980, 1981, 1982) annual surveys of research in mathematics education. The catalogue of theses in education at Ahmadu Bello University and an undergraduate bibliographic project of mathematics education research in Nigeria (Adeniran *et al* (1983)) directed attention to some local work. However, as stated in Section 2.3.6.1, the lack of comprehensive catalogues of educational research in West Africa probably has led to the omission of some very relevant works.

2.4.2 Research Design, Methodology, and Data

The research design is discussed in Section 3.2. Four main references led to the present design in varying degrees of specificity. Shumway (1980) offers general guidance and recommendations for research in mathematics education, including chapters on the research process, case studies of different types of research designs, and summaries of research problems of current interest. Campbell and Stanley (1963) has become a standard reference on different types of research designs and includes discussions of advantages and potential flaws in each. Some of these are mentioned in the discussion of the research design. Two sources noted in this chapter were particularly useful in planning the research: Fullan and Pomfret (1975) on methodological problems in research on curriculum implementation, and Hansen (1975) who investigated some variables similar to those of the present study.

Some background information on the area of the case study was obtained from Hanson (1973), which, though old, was the most comprehensive collection of information on post-primary teachers in Nigeria that could be found. Less detailed but more recent were reports from some states on mathematics education and mathematics teachers in Ale (1980). Two undergraduate projects also were useful descriptions of the case. Adagaba, et al (1980) surveyed teachers' college mathematics teachers in five states, and Aduanya, et al (1982) collected data on qualifications, age, gender, nationality, etc. for post-primary teachers in nine states (n=974).

Data collection proved to be a difficult exercise (see Section 5.3.2.3). However, some warnings of the difficulties came from Shipman (1974), which is discussed in Sections 2.3.4.3 and 2.3.5.5. Shipman warned of teachers not being ready to supply data or to otherwise cooperate with the research. More locally, Ozumba (1974) in Lagos, describes the difficulties in getting teachers to complete a sixty-item questionnaire, and, prior to that, the problems of even obtaining statistics on the size of his population and of simply meeting the principals and teachers. Fullan and Pomfret (1975) discuss problems of measurement of implementation by the use of questionnaires, such as the dangers of relying on self-reports, but they noted the value of questionnaires if the sample is large and wide-spread.

The type of data collected in this research also reflects findings from Fullan and Pomfret (1975) and from Shipman (1974). Their discussions of the role and value of teacher participation in curriculum development and implementation and teacher reactions to new curricula are summarized in Sections 2.3.4.3, 2.3.4.4, and 2.3.5.5. Some of the reported teacher reactions - attitudes and levels of participation - were directly incorporated into some of the individual items of the instrument (See Section 3.4.2, Appendix D). In addition, Fullan and Pomfret support the inclusion of measurements of teacher knowledge about new curricula in studies of implementation. Knowledge may be considered as an independent variable (which is its main role in the present study), but it also may indicate a deeper measure of the degree of implementation - understanding the philosophy and meaning of the new curricula as well as simply acting out the behavioural forms of new programmes.

2.4.3 Theories of Attitude Change

The measurement of attitude and attitude change is a more subtle and psychological aspect of the study, as compared to the more straightforward, even factual, measures of teacher knowledge and participation in the curriculum development process. Hence it is appropriate to discuss attitude measures and the theories of attitude change in more detail, especially as they apply to this research.

Secord and Backman (1964) offer a good summary of studies on attitude and attitude change. Attitudes have affective, cognitive, and behavioural components, all of which might be seen in accepting a new mathematics curriculum. An accepting teacher would like the new programme and feel at ease using it; he would need to learn the new content associated with the new programme; and his teaching behaviour would probably be modified to fit new methodologies.

Since attitudes are hypothetical constructs, they cannot be observed directly, but may be inferred from behaviour or may be indicated by self-reports in the form of an attitude scale. Some informal observation of behaviour is included in the present study, but the formal experimental part uses an attitude scale. The type used is the common Likert scale, developed by Likert (1932). For this research, the guidelines developed by Edwards (1957) were used in item-construction and Shrigley and Trueblood's (1979) recommendations provided additional assistance. The former discusses attitude-measurement and item-construction in general terms, while the latter is drawn from the authors' experience in measuring attitudes toward metrication.

Several theories to explain attitude change have been developed, some of the most important of which are described in Secord and Backman (1964). Festinger (1957) developed the theory of cognitive dissonance in which a person feels an inconsistency between two or more of his opinions, beliefs, or items of knowledge. This dissonance may be removed by changes in the person's behaviour, by his seeking a change in his environment, or by adding additional items of cognitive knowledge to overbalance the points of inconsistency. It might be argued that a workshop atmosphere of teachers learning about details of a new curriculum, with positive support of their peers, would reduce any dissonance between a teacher's doubts about a new programme and his expected behaviour of starting to use it.

Katz (1960) offers a functional theory of attitudes where he postulates that the holding of a particular attitude serves a purpose for the individual, perhaps helping him gain reward or avoid punishment; hiding unpleasant truths from himself; giving him a chance to express his values; or to provide a consistent structure to his experience. For example, it has been suggested that teachers may oppose a new programme not so much because of actual faults they perceive in it, but more because of their own self-doubts and insecurity in trying something new. By providing more training and support, a workshop may help remove this doubt.

A three-phase process of attitude change was suggested by Kelman (1961). He listed (a) compliance, which is taking a particular attitude primarily to satisfy a higher authority; (b) identification, or adopting attitudes and behaviour because they are connected with a satisfying relationship to a person or group; and (c) internalization, when attitudes fit directly into a person's own system of beliefs and values. A teacher may accept a new curriculum by compliance with a ruling from the Ministry of Education, but unless he internalizes his acceptance, he may not enthusiastically follow the recommendations of the new programme.

Some of these theories of attitude change have been used in studying effective treatments for attitude change. Recommendations resulting from these studies provide suggestions for improving the organization and presentation of teacher workshops for curriculum change. Hovland, Janis, and Kelley (1953) pointed to two characteristics of the "communicator" which are needed to lead people to change attitudes. They asked for expertness and trustworthiness. Expertness may come from the status, education, training, or occupational position of the communicator; while trustworthiness may result from personal characteristics, assumed motives, or, again, status, of the communicator. Shipman (1974) also referred to the status of "people from the university" as both helping and hindering acceptance of a project, depending on the teachers viewing them as a source of prestige or as researchers with academic motives. Also, a curriculum implementer may be looked upon as a commercial agent of publishers of new textbooks, an experience felt (without justification) by the researcher in earlier work in Sierra Leone. Perhaps increased contact between teachers and curriculum developers can help the developers gain the trust of the teachers.

The content organization of a teacher workshop can also benefit from findings on structures of presentation of arguments for attitude change. Secord and Backman (1964) point out that, though evidence is not conclusive, usually a presentation is more successful if at least it mentions both sides of an argument. An important exception is the usual practice of advertising to present only one side with apparent success. In the case of a curriculum change workshop, this would mean including discussions of the difficulties of accepting the new programme along with the praise of its advantages.

Although an organized group may hinder propagation of new ideas which are contrary to group ideals, a workshop is generally an _ad hoc_ group, gathered only for the purpose of the workshop itself. Lewin (1958) showed that in such cases, group pressure can act to support change, especially if much group discussion and participation is involved, and all have the opportunity to express themselves freely. As seen in Chapter 3, these social-psychological guidelines on attitude change are reflected in the organization of the workshops of the present research.

2.4.4 Analysis and Conclusions

After the data were collected, they were analysed statistically, as reported in Chapter 4. The analysis was guided by various books on inferential statistics, especially Glass and Stanley (1970), which is a good reference not only because it is very comprehensive in its coverage, but also because it is aimed particularly at the use of statistics for research in education and psychology. Also, Yeomans (1968) and Ferguson (1981), which is also oriented toward educational studies, proved to be helpful. Notes on the statistical techniques are given in Appendix G.

Conclusions and recommendations depend, of course, on the results of the technical analysis of the data. However, policy recommendations must also relate to other current statements of policy and recommendations for action. An important statement of suggestions for work in mathematics education is NCTM (1980) which pinpoints and discusses eight major issues to be faced by mathematics educators in the 1980s, including (Recommendation 7) the need for a higher level of professionalism among teachers of mathematics. This is supported by NCTM (1981), a survey of priorities in school mathematics, which notes that "in-service education for teachers was given first priority in attacking mathematics education problems, followed by pre-service education". (NCTM (1981) p.33).

The background for the recommendations in curriculum implementation are discussed at length in Section 2.3. The major sources for direction are Shipman (1974), G. Williams (1974), Dalin (1975), Reid and Walker (1975), Fullan and Pomfret (1975), B. Young (1975), and Hawes (1979).

Most specific to the relationship of the findings to the situation in Nigerian mathematics education is Shirley (1980b), which was written at the same time as ideas for this current study were being developed. The recommendations of that paper are reiterated more strongly in the conclusions of the present study. The National Conference of Mathematics and Mathematics Education approved a list of resolutions (Ale (1980)) which also contributes to the thinking behind the recommendations of this study.

Finally, the report (Adaralegbe (1972)) of Nigeria's 1969 historic national curriculum conference and the National Policy on Education (1977, 1981) which eventually resulted from the discussions begun at the 1969 conference, must always be considered as they represent the basic documentary references for educational planning and curriculum development in Nigeria.

Chapter 3

PROCEDURE

3.1 Introduction

This study was developed from the author's previous experience in one programme of introducing new mathematics curricula. That earlier work led to a desire to learn of the practices and techniques employed elsewhere in similar programmes, with a hope of seeing which approaches seemed most advantageous for successful implementation and for general improvement of curriculum and instruction.

There are four parts to this study, all equally important in terms of knowledge to be gained about curriculum implementation. These are (a) the library research on previous work in mathematics curriculum development and implementation; (b) the further library research on theories, models, and case studies of the processes of curriculum implementation; (c) the survey-based case study experiment of measuring teacher response to the new curriculum in mathematics for teachers' colleges, with workshops for the teachers serving as the experimental treatment; and (d) the practical experience of actually planning, arranging, and conducting the series of workshops to use for the experiment of item (c) and to assist with the current campaign of introducing the new mathematics curricula in Nigeria.

The first two parts, the library research in mathematics curriculum and curriculum implementation, have been reported in Chapter 2, and the findings from these are further discussed in Chapter 5. The present chapter describes the procedures and arrangements of the third and fourth parts, the experiment and associated workshops. Since the workshops also were the treatment part of the experiment, they are described at the appropriate point in the discussion of the experimental procedures.

Briefly, the experiment attempts to see if any relationship exists between mathematics teachers' knowledge of a coming curriculum and their previous participation in its development, on the one hand, and their attitude toward accepting the new curriculum on the other. The workshop is offered as a brief opportunity for teachers to learn more about the curriculum and to contribute to its further development. The effect of the workshop on the teachers' knowledge of the curriculum and their attitude toward accepting it are also measured.

3.2 Research Design

3.2.1 Basic Design

The experimental design is a case study, using a pre-test - post-test, control group design, mainly following the suggestions and warnings given in Campbell and Stanley (1963, pp.13-24). They point out that this kind of design covers quite well most of the dangers that can affect the reliability of a research study's findings. Barber (1973) also offers a list of "pitfalls" where lack of care in research procedures can influence the results. Some of these dangers and how they are avoided by this study are mentioned in the appropriate places below. Besides the pre-test and the post-test, a third test was also carried out to measure longer-lasting affects of the workshop. The schedule of the test and the details of their organization are described further below.

3.2.2 Measurements

3.2.2.1 Three Measures: Three main measures were made in each testing: (1) teacher participation in previous curriculum development work; (2) teacher knowledge of facts about content, philosophy, and development of the newest curriculum; and (3) teacher attitude toward accepting and using the new curriculum.

3.2.2.2 Participation: The first, teacher participation, attempts to determine the extent of personal involvement the respondent has had in curriculum development in mathematics. This includes participation in activities generally related to mathematics education and, more particularly, in actual planning and writing of new curricular materials. It is to be noted that this measure is not assessing the level of the teacher's activity in the experimental workshop, but rather his previous participation over a period of several years. For convenience, this measure will be referred to briefly as "Participation" or "P". The part of the instrument (Appendix D) which measures P is Section B, described in Section 3.4.1.2 of this chapter.

3.2.2.3 Knowledge: The second measure, teacher knowledge, is a factual test of what the teacher has learned about the specific new curriculum involved in the study. It asks about the actual content in general terms, about the overall direction and scope of the new syllabus, and some details about how it was developed and its current status. This measure will be called "Knowledge" or "K". It is determined from the results of Section C of the instrument (Appendix D), described in Section 3.4.1.3 below.

3.2.2.4 Attitude: The third measure, teacher attitude, does not attempt to assess the teacher's attitude toward mathematics nor teaching, but about his feelings toward changing the mathematics curriculum, assisting with the change, and actually accepting curriculum change and all the modification of teaching methods and other additional work that the change entails. This measure will be labelled "Attitude" or "A" and is found from the score of Section A of the instrument (Appendix D). It is discussed generally in Section 1-5-7; Section 3.4.1.1 discusses its measurement.

Generally, Participation and Knowledge may be taken as independent variables while Attitude is the dependent variable. However, in part of the analysis, Knowledge will be considered dependent on Participation. Also, all three may be considered as dependent on the effects of the experimental workshop. The measurement of these variables was done with a fifty-item questionnaire instrument which is described in greater detail in Section 3.4.

3.2.3 Treatment

Between the pre-test and the post-test, an experimental group of teachers attended a workshop especially organized as a part of this study. There were three almost identical workshops, one in each of the three states of the study. The workshops had the dual purpose of (a) familiarizing the participants with the new curriculum in the mathematics for teachers' colleges; and (b) involving the teachers in further development work through discussion and solicitation of their ideas and suggestions on how the "bare-bones" of the approved syllabus could be expanded and amplified into textbook and teacher-guide material, appropriate teaching aids, and effective instructional strategies. It was intended that the attending teachers should not only be told about the new curriculum, but should have a sense of being a part of its further development. Further details about the arrangements and content of the workshop programme are in Section 3.5.

3.3 Case Study

3.3.1 Description of the Case

3.3.1.1 Qualifications of Teachers: This research is a case study of mathematics teachers in the five-year, post-primary teachers' colleges in three states of northern Nigeria (See Appendix B for a list of the colleges). Ideally, such teachers should hold tertiary qualifications, academically in mathematics and professionally in education. Such qualifications in this setting would most commonly be a B.Sc.(Ed) or B.Ed. degree with subject specialization in mathematics; a sub-degree Nigerian Certificate of Education (NCE) from a post-secondary Advanced Teachers' College (ATC) or College of Education, also with mathematics subject specialization; or a Diploma or Higher Diploma in Mathematics Education, sub-degree tertiary certificates offered by Ahmadu Bello University in a programme aimed at relieving the shortage of post-primary mathematics teachers. This shortage in fact often means that the actual classroom teacher of mathematics may lack these qualifications, perhaps holding a degree without education credentials, a degree or NCE outside of mathematics, or perhaps no more than secondary or teachers' college qualifications. Such "unqualified" teachers may be recruited to fill gaps in mathematics staffs, even if teaching out of their fields. Also, it should be noted that a large proportion of the mathematics teachers in the area of the study are expatriates, also recruited when there are not enough Nigerian teachers available. (More serious, some classes have no regular mathematics teachers, except, perhaps a visiting NCE or degree student doing his teaching practice exercise.)

This study takes the position that new mathematics curricula are intended to be used by all teachers of mathematics - qualified or unqualified, Nigerian or expatriate. Hence, no group was excluded from the study. More discussion of teachers in this study is in Section 1.5.3; Section 4.6 discusses qualifications and other personal factors of the actual teachers whose responses were used in the study.

3.3.1.2 Teachers' College Mathematics: Teachers' colleges in Nigeria are five-year, post-primary institutions providing the academic and professional pre-service training to prepare primary school teachers. This type of school was chosen mainly because the new syllabus in mathematics for teachers' colleges (Federal Ministry of Education (1979)) is the least implemented of the four mathematics curricula approved by the Federal Ministry of Education in 1979. The primary and secondary curricula already have a variety of commercial textbooks based on their syllabuses and are already in use in some form in many states, but no books yet (1983) exist for the teachers' college syllabus (except for some preliminary teaching modules being developed by the National Teacher Institute; see Section 2.2.10). Hence this syllabus presents a better opportunity to observe a new curricula at the beginning of its implementation and still in the stage of expansion from its initial development.

3.3.1.3 Teachers: Teachers are the group within the educational system which is being studied, rather than administrators, students, or others, since the teacher is the one who actually puts a new curriculum into regular use. Administrators may make the decision to start a new programme, and some studies, such as Carlson (1964), do focus on the role of administrators.

However, having decided to use a new programme, the administrator still must rely on the ability and support of each classroom teacher to carry out the decision with a successful implementation. Similarly, one would hope that curriculum planners keep the abilities, interests, and needs of the students in mind in designing new programmes. However, it may well be that the teacher will be the one to inform the developers of the student characteristics, and in nearly all curricula, it is the teacher who brings the programme to the students and translates its goals into classroom experiences. Nearly all the relevant academic literature reviewed (e.g., Miles (1964), Shipman (1974), Fullan and Pomfret (1975), etc.; see Section 2.3, especially Sections 2.3.4. and 2.3.5) emphasize the significance of the teachers in curriculum implementation and development, not only for their knowledge and skill in using the new material, but also for their enthusiasm and support of the philosophy of the programme.

3.3.2 Description of the Location of the Study

3.3.2.1 Three States: In the early planning of this study, the researcher had planned to use only one state for the survey of teachers' college mathematics teachers and the organization of the curriculum development workshop. However, the coverage was extended to three states in order to:

(a) give the researcher a wider view and more experience in the curriculum implementation process; (b) strengthen the case for generalizability of the results; and (c) offer more assistance to the implementation efforts currently in progress. The increase from one to three states more than tripled the logistical complications of the research in terms of data collection and the workshop arrangements since the two added states were considerably farther from the researcher's base in Zaria.

The three states of the case study are Sokoto, Benue, and Kaduna States (It should be noted that these state designations are those in use at the time of the study (1981-83); the current campaign to create new states may change these designations in the near future) (See Figure 3.1). All three states are in the northern part of Nigeria and all have developed out of Northern Nigeria, the administrative region of colonial government and the early years of independence. Each of the states is briefly described in the following sections, especially in terms of the development of education.

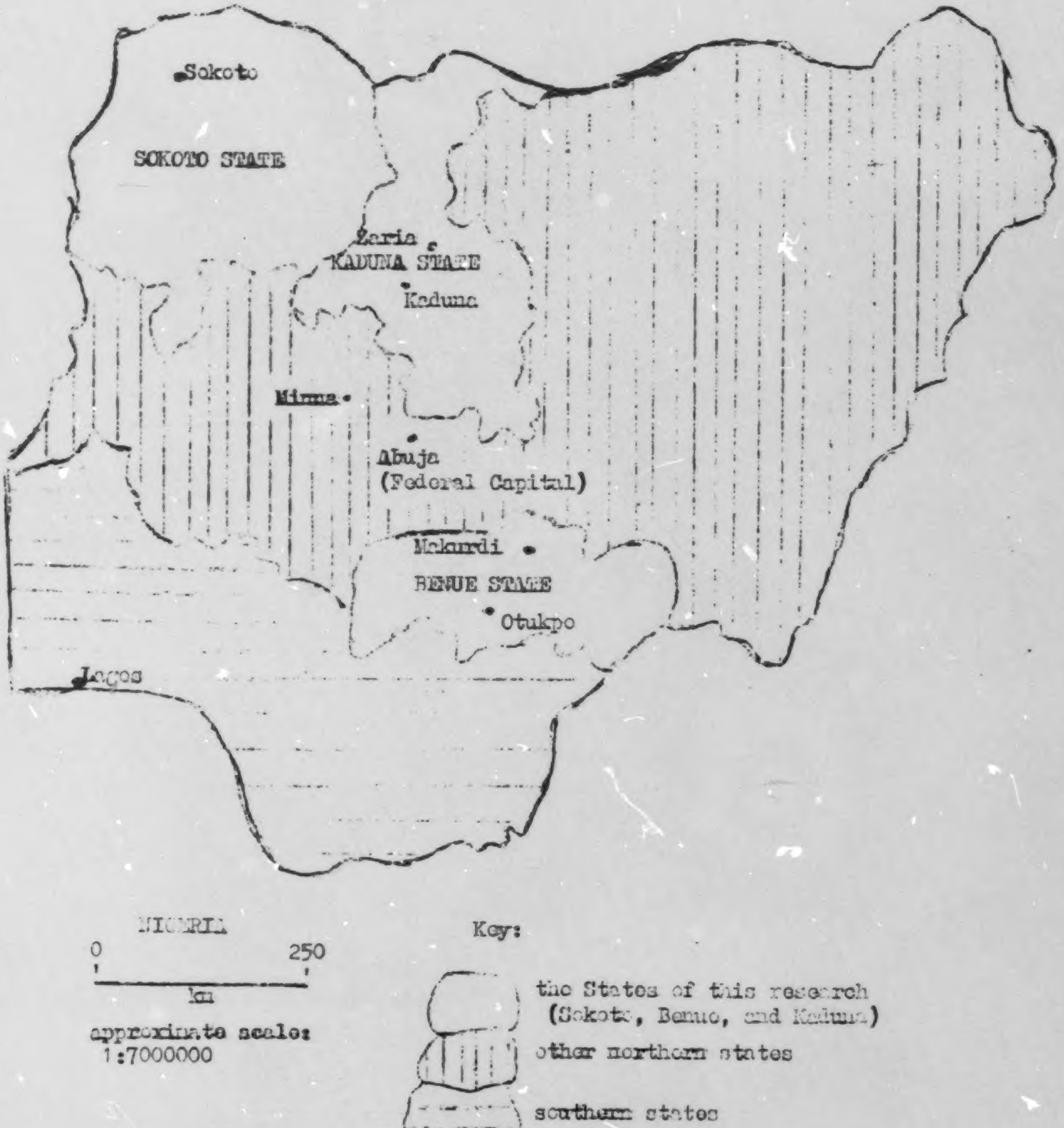
Sokoto
SOKOTO STATE
Zaria
KADUNA STATE
Kaduna
Minna
Abuja
(Federal Capital)
Makurdi
BENUE STATE
Otukpo
Lagos
NIGERIA
0
250
km
approximate scale:
1:7000000
Key:
the States of this research (Sokoto, Benue, and Kaduna)
other northern states
southern states

Figure 3.1 Nigeria

3.3.2.2 Sokoto State: Sokoto State has historically been a centre of Islamic religion and culture. In line with British colonial policy and prevailing religious sentiment, Christian missions were not allowed in this area for many years, and as a result, Western education, which was usually introduced in Nigeria by the missionaries, was late in coming to Sokoto. Thus, although Sokoto has been notable for Islamic scholarship, in the Western sense, it has been and remains educationally deprived. As recently as 1968, even figures for the former Northwest State (which also included the present Niger State along with Sokoto) showed only one medical doctor and five graduate teachers indigenous to the state (Hanson (1973) p.79). Rapid educational expansion in the past four years, has largely relied on the recruitment of foreign teachers. A survey in 1981 showed nearly three-fourths of the post-primary mathematics teachers to be expatriates, while only 17.5% were fully qualified Nigerians and only 7.9% were qualified Sokoto indigenes (Aduanya et al (1982) p.36). But progress is being made in Sokoto State: as of 1981, there were twenty-five teachers' colleges (See Appendix B) and also a Division of Extension and Support Services (DESS) within the Ministry of Education aimed at in-service teacher training and instructional support.

3.3.2.3 Benue State: Benue State, along with Kwara State, forms the southern edge of the former Northern Nigeria, lying mostly south of the River Benue. Since Islamic influence was much less in this area than farther north, Christian missions and schools came into the state in the first half of the twentieth century. The 1981 survey cited above found 66% of the post-primary mathematics teachers to be of Benue State origin (two-thirds of whom were fully qualified), 11% were other Nigerians, and 23% were expatriates (Aduanya et al (1982), p.35). At the time of this research, there were thirteen functioning teachers' colleges in Benue (See Appendix B), though six others were in various stages of being established.

3.3.2.4 Kaduna State: Kaduna State stretches from the international border with the Republic of Niger in the Muslim north to its southern end, next to the Jos Plateau, which is now largely Christian. Katsina and Zaria were important Muslim centres for hundreds of years; Kaduna (city) was built as the colonial capital of Northern Nigeria; and although there is a Muslim emir of Jema'a in the south, Christian missions came fairly early and established schools between Kachia and Kagoro. Even Zaria, while traditionally ruled by an emir, allowed early mission schools in nearby Wusasa, and later became a centre of education in the North, with many schools of all levels, including Northern Nigeria's first university, Ahmadu Bello. On a statewide basis, however, Kaduna State has been rather slow in educational development until quite recently. Figures from 1968 and 1969 showed only 11% of the children aged 6 to 12 attending primary school, and the existence of only thirteen secondary schools and nine teachers' colleges to serve the population of nearly five million (Hansen (1972) pp.118, 119, 123, 127). Recent efforts have expanded the number of teachers' colleges to twenty-four (See Appendix B), though the teacher shortage makes it difficult to adequately staff them. Aduanya *et al* (1981, p.35) found 45.6% of the mathematics teachers to be expatriates and 16.2% were less-than-fully-qualified Nigerians; 35.3% were qualified indigenes of the state.

3.3.2.5 School Administration: It should be noted that, coming from a common colonial history, the administrative structures of education, the system and curricula of teachers' colleges, and the sources of trained staff are all approximately the same across the state boundaries. All of the State Ministries of Education developed from the Northern Region Ministry of Education upon the state-creation exercises. All of the teachers' colleges have been loosely linked together under the Institute of Education of Ahmadu Bello University. Trained Nigerian teaching staff nearly all come from Advanced Teachers' Colleges or Colleges of Education, or one of the Nigerian universities, which, at their respective levels, offer similar academic and professional preparation to teachers going to all states. Also, all of the states have similar sources of foreign teachers.

3.3.2.6 Summary: It can be seen that the three states of this case study are geographically close, have had much common history in colonial times and since independence, and have had similar development of school systems, curricula, and teaching staffs. In all, Western education was first established by Christian missionaries and was often hindered by Muslim reluctance to admit Christian groups, and hence, even today, these areas are labelled as "educationally deprived". All followed the British colonial administrative patterns and as part of the Northern Region of Nigeria, they had a common Ministry of Education. Today, they continue to follow the same syllabuses and their students sit common examinations. Also, they all have large numbers of expatriate mathematics teachers, mainly to fill gaps in the local teaching staff which resulted from the earlier lack of Western education.

It should be especially noted that these similarities in history and structure of education, past British colonial rule, and shortages of local teachers extend to the other northern states of Nigeria. To a lesser but still considerable extent, these similarities hold for the rest of Nigeria, other English-speaking nations of West Africa, and even other Third World nations.

3.3.3 Experimental Groups

3.3.3.1 Selection: In each of the three states, questionnaires were distributed to all of the teachers colleges (see the list in Appendix B) with the request that all who teach mathematics should complete them. Special efforts, including personal visits to the schools, were made to encourage as high a response as possible.

With the cooperation of the three Ministries of Education, one mathematics teacher from each teachers' college was invited to attend the experimental workshop for his state. This group of teachers formed the experimental group for the measurements of the effects of the workshop (Hypotheses 3 and 4, Sections 1.3.2, and 4.5) while all the other teachers formed the control group. However, for measurements of correlation **of** past participation and knowledge with attitude toward curriculum change

(Hypotheses 1 and 2, Sections 1.3.2 and 4.4), all of the teachers' responses were analyzed together, since this aspect did not involve the workshops.

All three of the Ministries of Education requested this method of selecting workshop participants so as to treat all schools equally. In addition, this pattern of workshop attendance aids in the diffusion of information about the new mathematics curriculum. It approximates Schon's (1971) "proliferation of centres" model (Section 2.3.3.3) in theoretical terms, and the "echo-workshops" of the Philippines (Section 2.2.6.2) in that each teacher who attends the workshop can become a centre of diffusion back in his own school, "echoing" what he learned from the workshop, passing it on to his fellow teachers.

3.3.3.2 Similarities of the Groups: This method of selection gave a good cross-section representation of all the schools in the study area, but did not allow the researcher control of the selection within each school. Hence, randomness of selection cannot be claimed. However, to help build confidence in the comparisons of the results of the control group and the experimental group, an *ex post facto* comparison was made of the experimental and control groups to confirm that they did show similar characteristics prior to the experiment.

The three main variables of the study (described in Section 3.2.2) and three variables of personal factors (described in Section 4.6.1) were used for the comparison. The six variables briefly described are:

A - attitude toward accepting new curricula

P - past participation in curriculum development

K - knowledge of the newest syllabus for mathematics in teachers' colleges

E - highest level of training in education

M - highest level of training in mathematics

T - years of teaching experience

(note: The numerical scales for these variables are explained in Sections 4.3 (for A, P, and K) and 4.6.1 (for E, M, and T)

For each variable, the experimental and control groups were compared by using (1) a z-test of difference of means, and (2) an **F-ratio** of ratios of variances (See Appendix G for discussion of statistical techniques). Only scores from the pretest were used as they represent the base-line, before any interaction from the experiment. The results are shown in Table 3.3.

The relevant critical values are as follows:

z-test: for $\alpha = .05$, $z = 1.645$;

F-ratio for $df_1 = 43$, $df_2 = 34$: for $\alpha = .05$, $F = 1.74$

F-ratio for $df_1 = 34$, $df_2 = 43$: for $\alpha = .05$, $F = 1.71$

Comparison of the z_{calc} and F_{calc} values on Table 3.1 and the relevant critical values shows that:

(a) For the differences of means, only the difference in K values is significant (The differences in K values are not significant for $\alpha = .01$).

(b) For ratios of variances, none of the ratios are significantly above 1.

Table 3.1

Z - and **F-ratio** Values to Compare Means and Variance of Experimental and Control Groups in Six Variables

Variable	A	P	K	E	M	T
Control-Group Mean	72.75	2.93	1.93	2.63	2.79	11.07
Experimental-Group Mean	74.63	3.49	3.71	2.66	2.80	10.74
Control-Group St. Dev.	6.61	2.10	3.35	0.99	0.70	7.97
Experimental-Group St. Dev.	6.16	2.33	3.82	0.86	0.86	6.57
z_{calc} (difference of means)	1.29	1.12	2.20	0.14	0.05	0.20
Total df (z-test)	77	77	77	77	77	77
F-Ratio (of Variances)	1.15	1.23	1.30	1.32	1.49	1.47
df_1 (numerator)	43	34	34	43	34	43
df_2 (denominator)	34	43	43	34	43	34

n (experimental group) = 35; n (control group) = 44

If nationalities are compared between the experimental and control groups, the proportions of Nigerians show no significant difference between the groups. The experimental group had 14 Nigerians out of 35, **while** the control group had 13 Nigerians out of 44. These yield 40% and 29.5%, respectively. The z-test for difference of proportions (see Appendix G) yields $z_{calc} = 0.973$, which is far short of significance at $\alpha = .05$. Moreover, even if there had been a significant difference in nationality ratios, it probably would not be important, since it is shown in Section 4.6.3 that the different nationality groups produced few differences in the scores of the major variables.

These findings demonstrate that the experimental and control groups can be considered similar in the important measures of this study, even though their selection was not random.

3.4 The Instrument

3.4.1 Description

3.4.1.1 Section A - Attitude: The instrument for the experimental part of this study was a questionnaire (see Appendix D), completed by all responding teachers. The questionnaire consists of four sections. The first

(Section A) is a twenty-item attitude scale to measure the respondent's feelings toward accepting a new mathematics curriculum. As mentioned in Section 1.5.7, this measure does not intend to indicate the teacher's attitude toward mathematics or toward teaching, but only his response to the introduction of a new programme in mathematics. The word "new", always referring to "curricula", "programmes", or similar words, appears in fifteen of the items; the word "change" is in two of the remaining items; and the other three use other language to refer to the change of curriculum. The word "mathematics" (or "maths") appears in all but one item to emphasize specific reference to change in mathematics, rather than the more general process of curriculum change or educational innovation. To encourage personal reactions, the word "I" (or "me") appears in fifteen of the items, and the others also imply individual feelings. Seventeen of the items use a present tense verb to elicit immediate feelings; three items use a future subjunctive ("would like" twice; "would refuse"); none are stated in the past. The standard guidelines of Edwards' (1957) were followed as strictly as possible in constructing the items. Also, the structure of response follows Edwards' (1957) recommendations; i.e., a five-point scale of "strongly agree", "agree", "neutral", "disagree", and "strongly disagree". Twelve of the items are keyed as positive and eight are negative. This division is close to the desirable even split while avoiding the exact balance (which could influence responses). Also the pilot study (described in Section 3.4.3.1) showed some confusion in response to negatively-worded statements, so it seemed more reliable to use a larger number of positive items. The content of the items is discussed in Section 3.4.2.1; scoring is in Section 4.3.3.

3.4.1.2 Section B - Participation: Section 3 of the questionnaire (Appendix D) attempts to measure the respondent's past participation in curriculum development in mathematics. This is not an attitude scale, but a self-report of experiences over the past few years related to work on new mathematics curricula. There are twelve items. Each one has the word "I" and the word "mathematics" to stress the personal involvement and the specific subject-area of mathematics. Nearly all have words related to the development process: "development", "change", "new", "improving", etc. To emphasize that these items are retrospective over several years, nine of the items use a present participle verb form ("have contributed", "have served", etc.). There are seven positive-keyed items and five negative-keyed; a similar balance as in the attitude items of Section A (Section 3.4.1.1) for the same reasons. Since the respondent has either participated as an item suggests or has not, there is no need for a range of responses; hence, these items are to be marked "True" or "False" to reflect the respondent's experience. Section 3.4.2.2 discusses the content of the participation section and its scoring is discussed in Section 4.3.1.

3.4.1.3 Section C - Knowledge: The third part of the instrument, Section C, (Appendix D) is a straightforward test of the respondent's knowledge of facts about the content, philosophy, and development history of the new syllabus in teachers' college mathematics (Federal Ministry of Education (1979)). There are eighteen items, approximately evenly shared among content, philosophy, and development of the syllabus. Respondents are to answer "Yes", "No" or "Don't Know", based on their own understanding (or lack of understanding) of the new curriculum. During the administration, they were discouraged from guessing answers, but rather told to select "Don't Know" if that were the case. These items are keyed to have eight "Yes" answers and ten "No". The content of the items is discussed in Section 3.4.2.3 and the scoring of this section is described in Section 4.3.2.

3.4.1.4 Personal Data Section: The final section of the instrument (Appendix D) asks for general personal data: name, school, nationality, state (if Nigerian), type of appointment, qualifications in education, qualifications in mathematics content, and teaching experience. It was necessary to ask for name in order to link pre-test and post-test results easily and it was hoped that other research findings might be derived from the additional data. Some of these findings are reported in Section 4.6.

To minimize the problems of lack of honesty or frankness which could come from lack of anonymity, these items were tactically placed on a separate page at the end of the questionnaire (a) to imply that it would be tabulated separately from the other sections, and (b) in the hope that many people might complete the other items before even noticing this page. To further imply its separateness, it was not called Section D. Finally, the instructions - both at the very beginning, before Section A, and again before this last section - point out that all the data would be held in confidence and only used statistically, and plead for honest responses.

3.4.2 Sources of Item Contents

3.4.2.1 Section A - Attitude: The content of the items in Section A of the instrument (Appendix D) attempts to reflect feelings often expressed by teachers in formal and informal discussions about the introduction of new curricula. The sources of the items came from both library research and practical experience. Shipman (1974) was the main library source for the item content (See Sections 2.3.4.3 and 2.3.5.5). In his discussions of teacher reactions to curriculum change he considers the pressures on the teachers in terms of the additional work of preparing new lessons and learning new content, the change of teaching methods, the concerns about standards, and the feelings of having the new programme imposed upon them without enough advance communication. These feelings are reflected in the items of Section A.

More positively, Shipman (1974) points to teachers who enjoy the challenge in the new programme (or at least the change from the routine) and to teachers who voluntarily helped to diffuse the innovation by explaining it to other teachers and assisting them in understanding it. Similarly, these kinds of attitude are also included among the items of the instrument. Fullan and Pomfret (1975) (Section 2.3.4.4) include similar discussion of teacher reactions.

The comments of Shipman (1974) and Fullan and Pomfret (1975) about teacher attitudes toward new curricula were easy for the researcher to accept and use because they also fitted well with his experience of hearing teacher comments about new curricula in both the more formal settings of workshops and informal chats in school staff rooms. Some of the items are almost direct quotes from these teachers' ractions over the past dozen years.

As the pool of items was developed, it was broken into six categories representing different manifestations of teacher attitudes toward new curricula. A rough balance of representation of these six categories was maintained in both the pilot version of the instrument and in the final version. The categories are:

(1) attitudes toward the extra work and time needed to start a new curriculum;

(2) attitudes related to content and examinations in the curriculum;

(3) attitudes about personal activity through workshops and service on committees;

(4) attitudes toward professional curriculum developers, academics, and education theory in new curricula;

(5) attitudes on individual curriculum development and on providing input or feedback about new curricula; and

(6) attitudes on helping to explain a new curriculum to others and convince others to accept it.

3.4.2.2 Section B - Participation: The items of Section B of the instrument (Appendix D), on participation, also are derived from both other research and experience. The items describe the various types and degrees of teacher participation in curriculum development - simple awareness of the work going on to actual writing of new material. Again, Shipman.(1974) and Fullan and Pomfret (1975) provided the main source of ideas for items, especially the latter's comparative review of the kinds of teacher participation in new programme design. The researcher's experience helped to fit these foreign examples into the Nigerian process of curriculum development. Also, the language used was an attempt to reflect typical teacher descriptions of their participatory experience (and their reasons or excuses for not participating).

As in the attitude items, the participation items were also sorted into categories, here representing different ways the teachers may have participated in the process of developing the new mathematics curricula. The four categories are listed (the numbering continues from the six categories of attitude items (Section 3.4.2.1)):

(7) giving suggestions to developers or personally writing material;

(8) attending meetings or serving on committees where curriculum development takes place;

(9) helping with the diffusion of the new programme; and

(10) general indications of participation (or lack of participation) in the curriculum development process.

Again, as with the attitude categories, these categories are approximately even in their appearance as types of participation items in both the pilot and final versions of the instrument. The categories are indicated for each item in Appendices C and D.

3.4.2.3 Section C - Knowledge: The items of Section C of the instrument (Appendix D), as indicated in Section 3.4.1.3, are facts about the Teacher Education Mathematics Curriculum (Federal Ministry of Education (1979)) and its development. The items relating to its content come from a reading of the syllabus itself. The items about its guiding philosophy also can be inferred from the syllabus, its Forward, and general public discussion of the programme. Some of this information is in Section 2.2.11. The historical points are also general knowledge among mathematics educators in Nigeria, especially those who have either been involved or have made an effort to keep informed. The historical facts include information reported in Section 2.2.10.

3.4.3 Development to the Final Form

3.4.3.1 Pilot Test: The original pilot version of the instrument was prepared from the sources described in Section 3.4.2. It consists of eighty-two items: 40 for Attitude, 24 for Participation, and 18 for Knowledge.

The sixty-four items of Attitude and Participation are mixed together under one set of instructions and all required response from the five-point scale of agreement. This preliminary instrument was tested at a workshop organized by the Niger State Ministry of Education in Minna in March 1981 for post-primary mathematics teachers of the state. The questionnaire was administered to the 28 teachers who attended the workshop and additional copies were given to the participants to carry to their colleagues for completion and return by post. Eventually, a total of 69 responses was received, representing roughly 60% of the post-primary mathematics teachers in [illegible] state. (It should be noted that Niger is also a northern state, **bounded** by Kaduna and Sokoto; Minna is shown on the map in Figure 3.1, page **167**)

3.4.3.2 Item Analysis: The returned pilot questionnaires were marked and given scores for Attitude and Participation. Item analyses were carried out separately for Attitude and Participation items for discrimination power. The methods of Edwards (1957) were used. For Attitude items, high and low groups of eighteen papers each (based on total Attitude scores) were used, and the sums of the high group scores and low group scores were found for each. The difference between the high and low groups' total scores gave the indication of discrimination power for each item. The same technique was followed with the Participation items except that the high and low groups had sixteen papers each since that allowed a sharper distinction of the group boundaries. The positively-worded and negatively-worded items for Attitude were ranked according to their discrimination indices. Selection of items for the final version of the instrument was based mostly on high discrimination indices, but also the rough balance of positive and negative items was considered. Less quantitatively, items which had brought out oral expressions of confusion from the Minna respondents were either not selected or clarified. In the pilot questionnaire, some pairs of items had been included which were direct opposites. In all cases, only one of each pair was selected.

Eventually, twenty Attitude items and twelve Participation items were selected for inclusion on the final instrument of the experiment. All eighteen Knowledge items were carried over from the piolot questionnaire to the final instrument. These items, being factual, have less need of comparative sorting for individual performance.

3.4.3.3 Format: In the final version (Appendix D) of the instrument, the three types of items were sorted into separate sections, so that instructions for each type could be made more clear. Especially it was desirable to separate in the mind of the respondent, reporting one's attitudes toward participation in accepting new curricula and descriptions of actual participation. Also, with this separation, the participation items were converted from the five-point response scale to a "true-false" response. This is because one's past activity is definite - one either participated or did not participate - and the five-point range of allowed response is superfluous.

3.4.4 Validity and Reliability

3.4.4.1 Content: The validity of a research instrument is an important factor in the success of any research. In the present case, the content validity is based on several parts of the process of developing the instrument. As described in Section 3.4.2, the item content was based on both the researcher's own practical experience with teachers and curriculum and on the reports of similar research elsewhere, especially Shipman (1974) and Fullan and Pomfret (1975). This led to an intuitive sense of content validity. The intuition was confirmed by requesting a group of twenty B.Ed. (Mathematics Education) degree students, all with post-primary mathematics teaching experience, to examine the proposed items. Based on their immediate understanding of teacher attitudes, they were asked to recommend modifications, deletions, and additions as the instrument was being developed, and their comments were noted in the preparation of the final version of the instrument.

3.4.4.2 Format and Phrasing: Also, a Senior Lecturer in educational psychology, with considerable experience in the development of questionnaires and attitude scales, checked through all of the original items and offered suggestions for improvement of content or phrasing of some items and otherwise approved the format, grammar, clarity, and balance of the items, and confirmed the positive/negative and subtopic classifications, as described in Section 3.4.1. As mentioned in that Section 3.4.1, the standard guidelines of Edwards (1957) were followed as much as possible, giving another basis for credibility of the items' content validity.

Furthermore, the item-analysis (Section 3.4.3) for the items' discrimination power, following the pilot testing of the instrument, led to the selection of the items most likely to measure accurately and precisely for use in the final version of the instrument.

3.4.4.3 Reliability: After all the data had been collected, the results of the attitude scale were subjected to a split-half test of reliability. The Pearson product-moment correlation coefficient between odd- and even-numbered items was 0.648, which, by the Spearman-Brown Formula, led to a reliability coefficient of 0.787, which is accepted as a satisfactory reliability for the often-tenuous measurements of attitudes. (See Appendix G for further details of the statistical techniques.)

To make sure that other configurations of items would not lead to higher reliability, the reliabilities were checked in the same manner for the same scale with various ex post facto deletions of some of the items which had results farthest from the overall item mean. However, none yielded any reliability coefficient as high as that of the entire twenty-item original scale. Hence, the scores, as taken, were retained for the further data analysis.

3.4.5 Administration

Data gathering was conducted by personal visits to nearly all teachers' colleges in the three states of the study, either by the researcher himself or by graduate research assistants. The research assistants were given specific briefings and annotated copies of the instrument so that they knew how to lead respondents through the completion of all the items. For example, in the pilot study it was discovered that two respondents had skipped one entire page of items, so care was taken to make sure that respondents in the experiment saw and completed all pages. Also, the researcher and the research assistants confirmed that respondents understood the five-point attitude response scale, the true-false participation response pattern, and the yes-no-I-don't-know response pattern of the knowledge section (with emphasis on making the "I don't know" choice if the respondent really did not know, rather than guessing "yes" or "no").

The first round of data collection - the pre-test - took place between the start of the school session and the experimental workshops, mostly during October, 1981. The second round - the post-test - came in the few weeks after the workshops. In Benue and Kaduna States, this was mostly in late November, 1981, and early December, but in Sokoto State, the workshop was held in late November, so the second round extended into January, 1982. The third round of data collection came during second term of the school year, mostly in February and March of 1982.

3.5 The Workshops

3.5.1 Rationale

The series of three Curriculum Development Workshops of the Teacher Education Mathematics Curriculum (Federal Ministry of Education (1979)) formed the centre of action of this research, the treatment part of the experiment, and the embodiment of the philosophical goals of the study. The workshops provided the researcher much practical experience in planning workshop presentation, gathering and preparing materials for workshop use, and making the official and logistical arrangements for workshops. Also, they served to test the possible changes of attitude and knowledge among the teachers of the experimental group who attended. Finally, the workshops formed an actual part of the implementation campaign for the new mathematics curriculum for teachers' colleges and attempted to aid the further development of the new curriculum by gathering suggestions and other input from the participating teachers.

3.5.2 Arrangements

3.5.2.1 Planning: Planning for the workshop contents and overall programme relied on the researcher's previous experience in organizing and participating in teacher workshops and from recommendations drawn from the literature review.

Shipman (1974) and Hawes (1979) (Sections 2.3.4.3, 2.3.5.5, and 2.3.6.2) were especially helpful. Also the various suggestions based on the social psychology theories of attitude change, discussed in Section 2.4.3, were taken taken into consideration. Finally, some specific references on in-service training workshops, mentioned in Section 2.3.7.3, also contributed to the planning.

Actually there were four, not three, workshops. The first was a "practice" or pilot workshop to try out the schedule of events, to make sure the materials were adequate, and generally, to seek evaluative comments from participants - and from self-evaluation by the researcher - to help make the actual experimental workshops proceed as smoothly and effectively as possible. The "practice" workshop was held on August 5-8, 1981. The participants were students of the B.Ed. (Mathematics Education) part-time degree programme who were completing their third long-vacation-term of classes. As part-time students, they all had been full-time teachers of mathematics in post-primary schools for the past several years and hence they represented a similar population to the group of teachers who would attend the actual experimental workshop. All of the handouts and visual aids planned for the regular workshops were used. The programme was almost the same as that planned for the coming workshops, with only slight modifications to accommodate the students' class timetable, and without the evening "entertainment" programmes.

At the end, the participating students completed an evaluation form (see Appendix E) and were encouraged to make other suggestions for the improvement of the workshop. Several modifications in the planned programme resulted from these suggestions, though the general design of the workshop received favourable evaluation.

3.5.2.2 Ministry of Education Connections: The three experimental workshops were held as follows:

Benue State: Government Teachers' College
Otukpo
October 28, 29, and 30, 1981

Kaduna State: Curriculum Development and In-Service Training Centre
Zaria
November 5, 6, and 7, 1981

Sokoto State: Division of Extension and Support Services Ministry of Education
Sokoto
November 25, 26, and 27, 1981

The Ministries of Education of Benue, Kaduna, and Sokoto States provided the official approval and support for the workshops in each of their states. Contact had been made with the Inspector for Mathematics of Kaduna State as early as March, 1981, and this was formalized by a letter to the Permanent Secretary of the Ministry of Education in August, 1981. Similar letters also went to the Ministries of Education of Benue and Sokoto States in August, 1981. (See Appendix A) The principal requests were for approval of the research work in general, including the collection of questionnaire data; and support for the workshops in the form of official invitation and requirement of teachers to attend, provision of a venue for the workshop with certain necessary facilities, and the payment of overnight and travel allowances for the attending teachers. Also, in each state, a high official from the Ministry of Education was invited to officially open the workshop.

The researcher paid personal visits to the Ministry of Education Headquarters in each state in late August and early September to deliver the letters and seek positive responses to the requests for assistance. Also the arrangements for the sites and dates of the workshops were made. Although there were inevitable administrative delays, the three Ministries were all most cooperative and helpful.

3.5.2.3 Problems and Successes, by State: A few of the specific administrative problems and successes in the three states are worth mentioning.

In Benue State, financial and other problems in the state delayed the opening of schools until about the middle of October. Hence, it was difficult, not only to gather first round questionnaire data, but also to invite teachers to attend the workshop (See Sections 4.2 and 5.3.2.2). This delay was partially compensated for by the unofficial reminders about the workshop sent out from Zaria by the researcher. Despite this, Benue had the lowest attendance and least representation of schools of the three state workshops, fourteen participants, representing seven schools. The Benue workshop was held on the compound of Government Teachers' College, Otukpo (shown on the map, Figure 3.1, page 167), the only workshop held at a school. The staff and students of the school were most hospitable and assisted in offering considerably more accommodation and feeding than had been anticipated. The workshop was opened by the state's Chief Inspector of Education.

In Kaduna State, the workshop was held at the state's only "teacher centre", the Curriculum Development and In-Service Training Centre (CDITC) in Zaria (shown on map, Figure 3.1, page 167). The early contacts with the State Inspector for Mathematics and the willing cooperation of the CDITC staff, especially the officer in charge of mathematics, made the arrangements for this workshop the easiest and smoothest.

Although there was a slight delay in the approval for the workshop invitations, their distribution was speeded by the Inspector delivering many by hand on his official round of school visits. Nineteen of the twenty-four teachers' colleges were represented at the workshop. The workshop was officially opened by the Permanent Secretary in the State Ministry of Education, the highest official in the Ministry at the time. His presence at the workshop not only raised the morale of the participants, but also attracted the television cameras of Nigerian Television Authority - Kaduna and the workshop received very good coverage on the state-wide news broadcast the following night. This additional publicity always helps to build general public awareness of the curriculum change and hence furthers the process of implementation.

In Sokoto State, arrangements were made with the Director of the Ministry of Education's Division of Extension and Support Services (DESS) in early September for the late November workshop. Unfortunately, due to a mix-up, official invitations were not sent out to the schools. However, unofficial reminders from the researcher and last-minute official messages succeeded in spreading the invitation. In fact, the Sokoto State workshop had the best school representation of the three workshops, twenty-three participants, representing twenty-one of the state's twenty-five teachers' colleges. The workshop was held at the DESS facility in Sokoto (see map, Figure 3.1, page 167). The mood of Sokoto State, and especially the state government, was subdued and sombre at the time of the workshop, as the state's Governor, Alh. Shehu Kangiwa, had died in a polo accident the previous week. However, the workshop did go on as planned, though without an official opening ceremony and without external publicity.

3.5.2.4 Logistics and Facilities: In all three states, certain logistical arrangements were provided by the Ministries of Education. These included a meeting hall with chairs, desks, blackboard, noticeboard; limited kitchen facilities for food and refreshments; certain stationery materials - file folders, some directional posters, note paper, etc.; award of certificates of participation (in two states); and allowances for participants' travel and accommodation. Unfortunately, except for local arrangements for beds in an unused hostel in Otukpo, no state was able to offer actual accommodation or on-the-spot cash for participants to pay for hotel rooms. All were only told they could submit their claims for allowances through their principals upon their return to their schools. Because of the usual delay in receipt of payment on such claims, this was the major complaint of the participants, and several reported difficulties in even finding accommodation.

The researcher provided, in cash and kind, the refreshments for morning tea breaks, and with the assistance of Otukpo staff and students in Benue and the researcher's wife in Zaria, he was able also to supply some free meals to the participants at surprisingly low cost.

It should be noted that the Curriculum Development and In-service Training Centre (renamed Educational Research Centre in 1982) in Zaria and the Division of Extension and Support Services in Sokoto, the sites of the Kaduna and Sokoto State workshops respectively, are the States' only units which resemble the "teacher centres" described at various points in Chapter 2. These are fairly new units and so far apparently used mainly for special events (such as these workshops). Both centres offered useful services to the workshops - especially of having the needed facilities and staff assistance conveniently available. (The workshop at which the pilot instrument was tested was held at a similar facility for Niger State in Minna.) More discussion about "teacher centres" such as these is included in Chapter 5 with some recommendations for more effective use of such centres (Sections 5.4.5 and 5.5.3).

3.5.3 Materials

Nearly all of the materials for the content of the workshops was prepared and assembled by the researcher in Zaria and carried to each of the workshops. Hence, once he arrived at the workshop-site with his trunk-full of supplies, everything necessary for the presentation was readily available.

There were three mimeographed handouts for each participant - a programme of events (Appendix F), a copy of the introductory paper (a slightly revised version of Sections 2.2.10 and 2.2.11) and a copy of the Teacher Education Mathematics Curriculum (Federal Ministry of Education, (1979) mimeograph format (1981)). The programme, in a booklet format, included a welcoming statement, the actual listing of the times of workshop events, and a list of useful addresses for the participant's future correspondence on curriculum development (publishers, mathematics associations, Ministry of Education agencies). The background paper summarized the historical development, over the past few years, of the new syllabuses in mathematics, and a discussion of how the contents of the new syllabuses satisfy the needs that had led to their development. Since the nation-wide distribution of printed copies of the new syllabus has been rather limited due to a small press run, the researcher transferred the entire contents of the printed syllabus to mimeograph stencils and then printed enough copies for all the workshop participants (and more). No content was omitted, but the contents were arranged into a division by major topics and subdivided by school-years, rather than the printed format divided into years and subdivided into major topics. This rearranged format was considered more useful for the purposes of the workshops since the participants would be working with particular topic assignments covering the entire five-year programme of the syllabus.

Also, the researcher brought some posters which demonstrated, in flow-chart style, the process of the development of the new mathematics syllabuses (a similar diagram was included in the copies of the background paper). The workshop trunk also contained a small reference library of old and new school mathematics textbooks, teacher-guides, and workbooks; some books on mathematics teaching methodology; and some recent research reports on instructional practices in mathematics. Finally, there were also materials for the two evening programmes (tape cassette, notes, and more poster display materials).

3.5.4 The Programme

3.5.4.1 Opening: The programme of events was very nearly the same in all three of the workshops - all used the same printed programme (Appendix F) and all succeeded in keeping quite close to the planned timetable.

As participants arrived, they were each given their packet of materials - the papers described in Section 3.5.3 plus a name-tag, all in a file folder. Their names and schools were recorded on the registration sheet. Formalities began with the opening ceremony in which a high official of the State Ministry of Education opened the workshop with remarks related to the need for improvement in mathematics education and the purposes of the workshop. Representatives of the hosting centre greeted the participants and welcomed them to the site. The researcher, who served as the workshop coordinator, also welcomed the participants, and explained the details of the timetable and other logistical arrangements.

3.5.4.2 Background Paper: Following a refreshment break, the real business of the workshop began. The researcher presented his paper which summarized the felt needs that had led to the development of the new curriculum and the major philosophical and content features of the new programme that answered these needs (The paper is a slightly revised version of Sections 2.2.10 and 2.2.11) This introductory presentation, accompanied by a large poster showing the pattern of the curriculum development, was intended to justify the development of the syllabus and familiarize the teachers with the major themes of the syllabus and the history of its development.

Before adjourning for a lunch break, the participants were divided into small groups, between four and seven groups of about three members each. Each group was assigned subtopics from the general areas of "Algebra" and "Geometry/ Measurement". These subtopics would be their main concern during the group work of the second day. This is described in more detail below.

3.5.4.3 Methodology Discussions: The group work of the second and third days of the workshop was entirely devoted to the mathematical content of the syllabus and its presentation. However, one important part of the teachers' college mathematics syllabus is the section (appearing in Year Four and Year Five) on the methodology of teaching primary mathematics. Hence the afternoon session of the first day of the workshop was given over to consideration of this "Methodology" section. Each of the subsections of "Methodology" in the syllabus were examined in turn. The coordinator pointed out the major points of each subsection and the workshop participants were encouraged to comment on these points, their value, how they could be interpreted in methodology lessons, and how they fit in with both theoretical and practical experiences for the students of teachers' colleges, to help give them better preparation for the teaching of mathematics.

In addition to providing special emphasis to this often-overlooked aspect of teachers' college mathematics education, the discussion session on "Methodology" was also intended to serve as a model for the kind of discussion each small group would participate in the following day - considering the points of the syllabus and offering suggestions on how it could best be presented. During the discussion on "Methodology", the coordinator also served as secretary, recording the main suggestions and recommendations from the group, and pointing out that, on the following two days, each small group should also have one member be a secretary to record its suggestions.

3.5.4.4 Discussion Groups: The second day of the workshop, without the hindrance of the formalities of the opening day, started earlier and moved directly into the major work of the workshop. The coordinator gave a brief summary of the important points of the "Algebra" and "Geometry/Measurement" sections of the new syllabus, which the participants had been told to study overnight in preparation for the second day's work. Then, after more instructions on what they were expected to do, they broke into their pre-assigned small groups, each to work on particular subtopics of "Algebra" or "Geometry/Measurement". They were told to discuss their given topics and make suggestions of some (or all) of the following types:

a) ways of introducing the topic

b) specific ideas on teacher presentation of the topic

c) applications and uses of the topic

d) actual examples for class discussion

e) actual experiences for student practice

f) ideas for teaching aids

g) sequencing of the various parts of the topic

h) problems to watch out for and how to avoid them (for teachers' and students' difficulties)

i) other comments on the topic

They were to think of their ideas as recommendations for possible use in forthcoming textbooks, teacher-guides, or teaching aids; in fact, the coordinator/researcher promised to collect and hold their suggestion for possible submission to textbook-writing projects. The suggestions were to be based on the new syllabus as it presently stands; however, if they had recommendations for actual changes in the given syllabus or other general recommendations, these were to be included separately.

The participants were warned that even their comparatively small sub-topics still represented much content and they were not expected to cover everything within their assignment in the limited time available. Considerably more time would be needed for thorough coverage, especially considering the rather long list of types of suggestions they had been told to work on.

The participants enthusiastically set to their task and worked hard throughout the remainder of the morning, even continuing their discussions as they took their refreshments at mid-morning.

3.5.4.5 Group Reports: After the lunch break, the plenary session resumed and representatives of each small group presented oral reports of the groups' suggestions. General group response was encouraged. This session caused the only serious problem in keeping to the planned timetable, as many participants wanted to join in the discussions and it was difficult to limit the remarks to the short times allocated for each group. Although on occasion the group presentations wandered into the actual attempt at teaching the content to the plenary group rather than concentrating on how to teach it, generally the delays were valuable as it gave the participants more opportunity to express their own ideas and to learn from the ideas of others.

3.5.4.6 More Discussion and Reports: Before the close of the second day's afternoon session, the group was divided into a new set of working groups, about the same number and size as before. Each group was given a new assignment of subtopics chosen from the areas of "Number", "Statistics", and "Inference" in the syllabus. These areas were highlighted briefly by the coordinator and the groups were told to be ready to do the same kind of discussion and suggestion-making as they had done with their first assignment.

The sessions for the third day were to finish at mid-day, so work began even earlier and the small groups immediately set to work. The instructions were the same as for the small-group work of the second day (Section 3.5.4.4). The groups worked till late morning, taking refreshments along with their discussions again, and then reassembled for more small-group reports to the entire group. Again, these reports and the responses from the group tended to go overtime, but generally the participants had learned from the previous day's experience to limit their remarks to the essential elements.

3.5.4.7 Closing: Finally, the coordinator offered closing remarks, thanking the participants for their fruitful collections of suggestions and recommendations. But also, he reiterated with emphasis that the individual teacher need not feel left out of the curriculum development process; that attendance at conferences can provide a chance to contribute; that curriculum developers and publishers are eager to hear from "the field" (the list of addresses participants were given should be used to send in comments, complaints, and suggestions); and that the products of these three workshops alone would be a wealth of material to guide future textbook-writing exercises.

3.5.4.8 Work at a Workshop: The researcher had especially designed the programme of the workshop to include much work; i.e., much direct participation of the attending teachers. Partly this was due to practical requirements: the workshop, as a tool of an individual's research, was necessarily largely a "one-man" production, and it would have been difficult for the researcher and boring for the participants for the coordinator to present one talk or demonstration after another.

But, on more theoretical grounds, it was felt that direct, active participation is the best way to learn.

By sitting down in small groups with a specific assignment and limited time, each participant was pushed into giving serious thought about the topics of the new syllabus, to organizing these thoughts into personal contributions to his group (no one can hide in a group of three), and to deal directly with the problems of the presentation of the material. It was hoped that this immediate kind of working contact with the new syllabus would help make the syllabus more solidly a part of the participant's intellectual and practical experience. Fullan and Pomfret (1975), and especially their report on the findings of Duet (1972), clearly support this kind of active work in teacher participation in curriculum development, and of course, this kind of active learning is recommended by Piaget, Bruner, and others for education in general.

The major fear on the part of the researcher was that the participants might feel overworked and balk at the continued assignments given to them. However, it seemed that these fears were not realized as the participating teachers generally worked with surprising enthusiasm, holding vigorous debates in their small groups, producing sheaves of written suggestions, speaking up in the large group reporting sessions, and only complaining that they did not have enough time to do a better job.

3.5.4.9 Evening Programmes: As a break from the work of the workshop and as a reminder that mathematics can also be entertaining, two evening programmes were held, on the first and second nights of the workshop. These programmes were both mathematical in content and loosely linked to more creative teaching of mathematics. They were not intended to relate in any direct way to the major themes or activity of the working sessions, though the researcher happily noted that some participants did draw some parallels to the curriculum development work.

The first programme was on "Number Lattices", based quite directly on the article of the same name by David Page (1966). The second night's programme was a tape recording, with a preliminary introduction and explanation by the coordinator, of "Metaphors and Analogies on Gödel's Theorem" by Douglas Hofstadter (1980). The tape recording was accompanied by posters drawn directly from the overhead projector transparencies used by Hofstadter in his original presentation.

The participants seemed to enjoy the programmes, both the humour of some of the examples and the challenge of some of the (often unanswered) problems. Also, the programmes provided a change from the day's mental exursions and an opportunity for the participants to chat and become better acquainted on an informal basis - which perhaps could encourage future interchange of visits and ideas after the workshops were finished.

3.6 Data Analysis

After the questionnaires were all gathered in, they were sorted according to state and control/experimental group to produce six groups. Within each group, the questionnaires were arranged in alphabetical order by name. This helped to collect together and organize the multiple forms from single individuals which resulted from the three rounds of data collection. Then all the groups were recombined in order and each questionnaire was given a serial number (1 to 305, the total number of questionnaires returned) and each individual respondent was given an individual number which remained the same for multiple responses from the same person for the three rounds. The Participation and Knowledge scores were obtained by hand, using cut-out templates to mechanize and speed the process and to reduce the chance of error in scoring.

For the scoring and analysis of the Attitude responses and most of the other tabulations and calculation required for the overall analysis, the researcher used a personal Sinclair ZX81 microcomputer. This had the advantage of always being available to the researcher (as long as the electric power stayed on), but the disadvantage of requiring the researcher to do all of his own programming as the software required for this work was not available. But that "disadvantage" was also advantageous in allowing the researcher to shape the programs, the input procedures, and the output displays specifically to the problem at hand.

The major programs devised and run were:

(1) loading the Attitude item responses from all 305 questionnaires;

(2) scoring Attitude, calculating parameters, checking split-half reliability in several configurations of the Attitude items;

(3) loading the Attitude, Participation, and Knowledge scores along with serial number, individual number, round of administration, state, control/experimental group, and personal data for all 305 questionnaires;

(4) calculating correlation coefficients for various combinations of the main variables;

(5) calculating various "before-and-after" mean scores of the pre-test, post-test, and third test results for the variables;

(6) calculating correlations of the personal data variables among themselves and with the main variables;

(7) calculating means of the main variables and the correlations among these variables, by state;

(8) calculating means of the main variables and personal data variables by nationality groups and comparing all the pairs of means;

(9) calculating partial and multiple correlations and regression lines for A with P and K; and

(10) calculating z-values and **F-ratio** for differences of means and ratios of variances, respectively, of main variables and personal data variables to compare control and experimental base-line values.

With results from these calculations and with the guidance of Yeomans (1968) and more particularly Glass and Stanley (1970) for techniques of statistical analysis, the four hypotheses (Section 1-3) were tested and other related results were found. Throughout the study α, the level of significance, was taken as .05. All of these tests and results are reported in Chapter 4. Also, the reliability check, reported in Section 3.4.4.3, and the base-line comparisons of the experimental and control groups, reported in Section 3.3.3.2, were all conducted. In all cases, the statistical techniques are mentioned briefly along with the results and are further described in Appendix G.

Finally, conclusions and recommendations were made, based on the review of literature, the experience of the workshops, and the statistical analysis of the data.

Chapter 4

ANALYSIS OF DATA

4.1 Introduction

The experimental part of this research consisted primarily of measuring responses of teachers of mathematics in teachers' colleges to items on the research instrument which referred to the teachers' previous participation(P) in mathematics curriculum development, their knowledge(K) of the new mathematics curriculum, and their attitude(A) toward accepting a change to the new curriculum. The groups of teachers; the three kinds of measures; and the content, structure, and development of the instrument are described in Chapter 3 (Sections 3.3 and 3.4). Similarly, the experimental treatment, three-day workshop for teachers in experimental groups, and the pre-test - post-test - control-group experimental design and procedures by which this design was carried out are also described in Chapter 3 (Sections 3.5 and 3.2).

This chapter reports the data which resulted from the various measures and attempts an analysis of these results.

4.2 Numbers of Questionnaires and Respondents

A total of 305 completed questionnaires were collected. Since some were pre-test and post-test measures, they represented a total of 202 individual teachers as respondents. In all reports of data results given in this chapter, the use of the word "questionnaire" or the note of n=305 means that the reported data is calculated from all returned questionnaires. If the words "individuals" or "individual respondents" or the note of n=202 is used, it means the results are from one questionnaire per person. If a person completed only one questionnaire, of course that one is used. If a person completed two or three questionnaires, only results from his first and earliest questionnaire are used, unless otherwise noted. In the case of the experimental group, this means that their pre-test data are used.

The breakdown of the total number of questionnaires by state and by experimental/control group is given in Table 4.1, while the same kind of breakdown for the total number of individual respondents is in Table 4.2. The smaller numbers from Benue State result mainly from the smaller number of schools in that state (13 in Benue State, compared with 24 in Kaduna State and 25 in Sokoto State) and from certain difficulties in arranging the administration of the instrument and the workshop (See Sections 3.5.2.3, 4.2 and 5.3.2.2).

Table 4.1

Categories of Returned Questionnaires

State	Experimental Group	Control Group	Total
Benue	24	27	51
Kaduna	34	93	127
Sokoto	38	89	127
Total	96	209	305

Table 4.2

Categories of Individual Respondents

State	Experimental Group	Control Group	Total
Benue	14	23	37
Kaduna	17	73	90
Sokoto	21	54	75
Total	52	150	202

As is discussed in Sections 4.5.1, 4.5.5, and 5.3.2, it proved impossible to reach every teacher in every round. Hence the average number of questionnaires per individual is only about 1½ instead of the desired 2 or 3. This limited the sample size for the before-and-after measures (see Sections 4.5.1 and 4.5.5), but did not reduce the correlation measures, which only required one response per person.

It should be noted that in some reports of individual personal data, in Section 4.6, the total number of individuals is only 198. This is due to the omission by a few individuals of the personal data section of the questionnaire.

4.3 Scoring

4.3.1 Participation

The Participation measurement is discussed in Section 3.2.2.2, and the part of the instrument which measured Participation is described in Section 3.4.1.2. Also, the meaning of Participation for this study in general is discussed in Section 1.5.6.

The twelve Participation items of the instrument were scored with one mark for each true-or-false response which reflected participation and zero marks for the opposite response. The sample questionnaire in Appendix D is keyed to show the responses that received marks of 1 or 0. Thus, a respondent's score on Participation (P) could be any whole number between 0 and 12. The mean P for n=305 was 3.59, with a standard deviation of 2.68. For n=202, the mean P was 3.46, with standard deviation of 2.47. The median P scores were 3.18 and 3.16 for n=305 and n=202, respectively.

The state-by-state results, by questionnaire, are shown in Table 4.3. It can be seen that all of the mean values of P are less than one-half of a standard deviation apart.

Table 4.3

Mean Values of the Participation Score (P), by State

State	Mean of P	Standard Deviation
Benue	3.14	2.70
Kaduna	3.30	2.60
Sokoto	4.06	2.68

4.3.2 Knowledge

The variable of Knowledge is discussed in Section 3.2.2.3, and Section 3.4.1.3 is the description of the part of the instrument which measures this variable.

The respondents were specifically instructed to mark "I don't know" if they really did not know the answer to Knowledge items in the instrument and were discouraged from guessing. Hence, correct responses were given 1 mark, "I don't know" received zero marks, and incorrect responses were given -1 marks, to counteract guessing. The correct responses are indicated on the sample instrument in Appendix D. Since there are 18 items, the possible range of scores is from -18 to +18; however, the actual range was from -6 to +16.

The mean Knowledge score (K) for n=305 was 3.20 with standard deviation 4.00; for n=202, mean K was 2.89 with standard deviation 3.52. For n=305, the median score of K was 2.72; for n=202, the median was 2.27. The state means of K are shown in Table 4.4 on page 219. Though not as close as the state means of P, even the extremes are still considerably less than one standard deviation apart.

Table 4.4

Mean Values of the Knowledge Score (K), by State

State	Mean of K	Standard Deviation
Benue	5.00	4.17
Kaduna	2.57	3.83
Sokoto	3.10	3.89

4.3.3 Attitude

Attitude was the dependent variable of this study and thus probably could be considered the most important of the three variables. Happily, the results for the scores of Attitude (A) came out with the least comparative variations between states. This variable is discussed in Section 3.2.2.4, while Section 3.4.1.1 has the description of the part of the instrument which measures Attitude. Also, Section 1.5.7 defines Attitude more generally for this study.

Respondents had to select from Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree for each of the twenty Attitude items in the instrument. The responses were scored 5, 4, 3, 2, and 1, respectively for the positive items and 1, 2, 3, 4 and 5, respectively, for the negative items.

Thus, the possible range of scores was from 20 (20 x 1) to 100 (20 x 5). The actual range was from 52 to 91. The positive and negative items are indicated on the sample instrument in Appendix D.

For n=305, the mean A was 72.53, with standard deviation of 7.38. For n=202, the mean A was 72.29 with standard deviation of 7.21. The median scores were 72.16 and 71.90, respectively.

As was done with P and K, the state means of A were also calculated and are reported in Table 4.5. The greatest difference can be seen to be less than one-third of a standard deviation.

Table 4.5

Mean Values of the Attitude Score (A), by State

State	Mean of A	Standard Deviation
Benue	72.47	6.41
Kaduna	71.50	7.16
Sokoto	73.58	7.79

By dividing the mean A values by 20, it can be seen that the single-item mean for Attitude was approximately 3.6, slightly onto the positive side. This is probably to be expected, given the natural human disinclination to appear negative. In any case, since the A values are used only in correlations and in comparisons, the actual location of the mean along the positive-negative scale does not affect the results of the present study.

4.4 Correlation Results

4.4.1 Technique

The first two hypotheses (Section 1.3.2) refer to correlations: between A and P in the first, and A and K in the second. For both, the Pearson product-moment correlation coefficients were found and z-values were calculated. The procedure is discussed further in Appendix G. These calculations were done both for the n=305 case of considering all returned questionnaires, and the n=202 case of using only one questionnaire (the first if there were more than one returned) from each individual respondent (as explained in Section 4.2). Probably the latter is a better measure as it avoids duplication and avoids influence from the experimental workshops; however, the results were similar in the two cases, so both are reported. As in Section 4.3, the two cases are distinguished by their different values of n (305 and 202).

4.4.2 Hypothesis 1

There is no significant correlation between the teachers' levels of participation in the curriculum development process (P scores) and their favourable attitudes toward the introduction of the resulting curriculum into the schools (A scores).

H_o: $\rho = 0$

H_a: $\rho > 0$

$\alpha = .05$, which sets $z_{.05} = 1.645$ as the boundary of the critical region.

$$z_{calc} = r\sqrt{n-1}$$

By questionnaires, with $n=305$, $\underline{r = 0.286}$

$\underline{z_{calc} = 4.98}$

By individuals, with $n=202$, $\underline{r = 0.227}$

$\underline{z_{calc} = 3.22}$

In both cases, $z_{calc} > z_{.05}$. Therefore the null-hypothesis H_o is clearly rejected, and the correlation is shown to be highly significantly positive at the $\alpha = .05$ level.

4.4.3 Hypothesis 2

There is no significant correlation between the teachers' levels of knowledge about the goals and content of the new curriculum (K scores) and their favourable attitudes toward the introduction of the curriculum into the schools (A scores).

H_o: $\rho = 0$

H_a: $\rho > 0$

$\alpha = .05$, which sets $z_{.05} = 1.645$ as the boundary of the critical region.

$$z_{calc} = r\sqrt{n-1}$$

By questionnaires, with n=305, $\underline{r = 0.257}$

$\underline{z_{calc} = 4.48}$

By individuals, with n=202, $\underline{r = 0.205}$

$\underline{z_{calc} = 2.91}$

In both cases, $z_{calc} > z_{.05}$. Therefore the null-hypothesis H_o is rejected, and the correlation is seen to be highly significantly positive at $\alpha = .05$.

4.4.4 State Results

In addition to the correlational calculations to test the stated hypotheses, further work with correlations was also carried out to produce additional results.

First, correlations between A and P and between A and K were calculated state-by-state with the results shown in Table 4.6. All were highly significantly positive at $\alpha = .05$ except r_{AK} for Benue. With that same exception, all showed stronger correlations than the overall results.

4.4.5 Participation vs. Knowledge

The P vs. K relationship was also calculated, both overall (n=305 and n=202) and state-by-state. Table 4.7 (page 225) shows these results. All are significantly positive at $\alpha = .05$.

Table 4.6

Correlations r_{AP} and r_{AK}, by State

State	r_{AP}	r_{AK}
Benue	0.357	0.196
Kaduna	0.584	0.370
Sokoto	0.777	0.560

Table 4.7

Correlations between P and K

Sample	r_{PK}
Questionnaires (n=305)	0.262
Individuals (n=202)	0.271
Benue	0.251
Kaduna	0.333
Sokoto	0.609

4.4.6 Multiple and Partial Correlations; and Regression

The multiple correlation of A with P and K and the partial correlations of A with P (K constant) and A with K (P constant) were also calculated. These results were as follows:

Multiple correlation $r_{A.PK} = 0.3425$

Partial correlations $r_{AP.K} = 0.235$

$r_{AK.P} = 0.196$

The linear regression line of A as a function of P is:

$$A = 69.700 + (0.788)P$$

For A as a function of K, the linear regression line is:

$$A = 70.943 + (0.496)K$$

The multiple linear regression line of A as a function of P and K is: $A = 69.057 + (0.647)P + (0.359)K$

An important point to note about these results is that although the combination of P and K raises the degree of correlation considerably, the contribution of P is substantially larger than that of K.

4.5 Pretest-Posttest Results

4.5.1 Technique

Hypotheses 3 and 4 (Section 1.3.2) both deal with the effects of the treatment - the three-day workshop for teachers. As described in Sections 3.2 and 3.4.5, the same tests of Attitude (A), Participation (P), and Knowledge (K) were administered to teachers who attended the workshop (experimental group) and to those who did not attend the workshop (control group), before the time of the workshop as a pre-test and again after the workshop as a post-test. Hypotheses 3 and 4 are concerned with any changes from the pre-test to the post-test in the scores of Knowledge (K) and Attitude (A) respectively. The statistical test consisted of measuring the mean differences of the individuals' pre-test and post-test scores. See Appendix G for more details.

It should be noted that the limited number of teachers who attended the workshops and the difficulties in reaching the same teachers twice (see Section 5.3.2) considerably reduced the number of subjects. The experimental group had n=35 and the control group had n=44.

4.5.2 Hypothesis 3

There is no significant change in the teachers' knowledge of the goals and content of the new curriculum (K score) after attendance at a three-day curriculum familiarization workshop.

Let d = the difference in the K scores from the pre-test to the post-test for each respondent

$$(d = K_{\text{post-test}} - K_{\text{pre-test}})$$

For the experimental group:

the mean difference $\bar{d} = 2.400$

the standard deviation of the differences $s_d = 4.257$

$n = 35$

$$z_{calc} = \frac{\bar{d}\sqrt{n}}{s_d} = 3.335$$

for $\alpha = .05$, it is necessary to use $z_{.025}$, since this is a two-tailed test.

$$z_{.025} = 1.960 < 3.335 = z_{calc}$$

Hence, the null-hypothesis is rejected. There is a significant positive gain in the K-scores from the pre-test to the post-test in the experimental group.

For the control group:

the mean difference $\bar{d}$ $= 0.227$

the standard deviation of the differences $s_d = 3.132$

$n = 44$

$$z_{calc} = \frac{\bar{d}\sqrt{n}}{s_d} = 0.481$$

For $\alpha = .05$, $z_{.025}$ is used in the two-tailed test,

$$z_{.025} = 1.960 > 0.481 = z_{calc}$$

Hence, the null-hypothesis cannot be rejected. There is no significant change in the K-scores of the control group between the pre-test and and the post-test.

4.5.3 Hypothesis 4

There is no significant change in the teachers' attitude toward the introduction of new curriculum into the schools (A-scores) after attendance at a three-day curriculum familiarization workshop.

Let d = the difference in the A scores from the pre-test to the post-test for each respondent

$(d = A_{post-test} - A_{pre-test})$

For the experimental group:

the mean difference $\bar{d}$ $= 3.371$

the standard deviation of the differences $s_d = 5.420$

$n = 35$

$$z_{calc} = \frac{\bar{d}\sqrt{n}}{s_d} = 3.679$$

Again, a two-tailed test is used, so for $\alpha = .05$, $z_{.025}$ is used.

$$z_{.025} = 1.960 < 3.679 = z_{calc}$$

Hence, the null-hypothesis is rejected. There is a significant positive gain in the A-scores from the pre-test to the post-test in the experimental group.

For the control group:

the mean difference $\bar{d} = -2.477$

the standard deviation of the differences $s_d = 5.332$

$n = 44$

$$z_{calc} = \frac{\bar{d}\sqrt{n}}{s_d} = -3.081$$

For the negative tail, if $\alpha = .05$, $-z_{.025}$ is used.

$$-z_{.025} = -1.960 > -3.081 = z_{calc}$$

Hence, the null-hypothesis is rejected, but note that there is a significant decline in A-scores of the control group between the pre-test and post-test.

4.5.4 Change in Participation Scores

No hypothesis was made about the pre-test - post-test differences in the P scores. This was because P is intended to indicate participation in curriculum development over a period of several years and it is tautological that by participating in a curriculum development workshop, the experimental group of teachers would be increasing their participation in curriculum development.

The results bore this out. The experimental group had a mean increase in P of 2.028 with a standard deviation of the differences of 2.990. With n = 35, this yields $z_{calc} = 4.015$, far above the limits of $z_{.025} = 1.960$, and hence very significantly increased. At the same time, the control groups P scores showed a slight drop, -0.341, with a standard deviation of the differences of 2.163. With n = 44, this yields $z_{calc} = -1.046$, which is not significant at $\alpha = .05$.

4.5.5 "Retention" Effects

Also beyond the stated hypotheses, an attempt was made to check "retention" or lasting effects of the workshop. A third round of administration of the tests was made approximately four months after the workshops. However, the difficulties in finding the same teachers for a third time made the sample size very small, n = 9 for the experimental group and n = 15 for the control group. The Student t distribution values were used instead of z values. Table 4.8 summarizes these results. Though the scores of the experimental group all dropped slightly, none of the changes, of any of the tests for either of the groups, were significant at $\alpha = .05$ (for $n = 9$, $df = 8$, $z_{.025} = 2.306$; for $n = 15$, $df = 14$, $z_{.025} = 2.145$.

Table 4.8

Score Differences between Post-Test and Third Test

test	group	$\bar{d}$	s_d	t_{calc}
A	experimental (n=9)	-3.667	6.092	-1.806
A	control (n=15)	0.133	2.156	0.239
K	experimental (n=9)	-1.333	4.082	-0.977
K	control (n=15)	0.333	1.886	0.684
Z	experimental (n=9)	-0.667	1.155	-1.732
Z	control (n=15)	0.000	0.516	0.000

4.6 Personal Factors

4.6.1 Scoring and Mean Values

The fourth section of the research instrument sought personal information from the respondents on their nationality, level of training in education, level of training in mathematics, and teaching experience. None of these factors were involved in the hypotheses, but it was decided to collect these data to check the relationships between personal factors and the Attitude, Participation, and Knowledge scores of the main study. Since a few respondents did not complete the section on personal data, these results use n = 198 (instead of n = 202). Since nationality is a categorization without numerical values, it is handled separately in Section 4.6.3.

The factor labelled Education (E) represents the highest level of training the respondent had received in formal professional education courses; e.g., teaching methods, curriculum, and other areas of education as a discipline. The results were scored as follows:

0 - no formal training in Education

1 - Grade II Teachers' Certificate (post-primary training) or equivalent

2 - Nigerian Certificate of Education, sub-degree Diploma or Higher Diploma in Mathematics Education, or other tertiary, sub-degree training

3 - degree work in Education - B.Ed., B.A.(Ed), B.Sc.(Ed), or Education as a subsidiary in another degree

4 - post-graduate study in Education.

Overall, the mean of E was 2.38, slightly above the level of NCE, and the standard deviation was 1.05.

The level of Mathematics training (M) was scored in a similar way as E. The factor of M represented the highest level the respondent had attained in formal academic work in Mathematics content. The following scores were assigned:

0 - less than secondary-level Mathematics

1 - secondary-level Mathematics (O-level, etc.)

2 - Mathematics at A-level, NCE, Diploma or Higher Diploma in Mathematics Education, or other tertiary, sub-degree study of Mathematics

3 - Mathematics to degree level

4 - Post-graduate study of Mathematics.

The mean M was 2.68, with a standard deviation 0.87; again, like E, between A-level and degree, though $\bar{M}$ was higher than $\bar{E}$.

Teaching experience (T) was measured by simply counting the total number of years the respondent had been teaching. This ranged from less than one year up to one claim of 34 years. The mean of T was 10.35 years, with a standard deviation of 7.40.

4.6.2 Correlations

Pearson product-moment correlation coefficients were calculated among all three of the personal data variables, E, M, and T, and between each of them and the major variables of the research, A, P, and K. The statistical techniques are discussed in Appendix G. Table 4.9 shows the matrix of correlations.

It appears that A is not closely linked to any of E, M, or T, though the correlations of A with M and T are barely significantly positive at $\alpha = .05$. It might be suggested that a willingness to try something new cannot be taught in academic coursework, and even time spent in teaching may or may not make one open to new curricula. Rather a more direct contact with the curriculum development process seems a stronger factor in more favourable attitudes.

Participation is most closely linked with M among the personal factors. Perhaps, people with higher levels of training in mathematics are more likely to be called upon to contribute to new programme development because of their greater expertise in mathematics content. However, P is fairly well correlated positively with the amount of training in education and number of years of teaching also. All three

Table 4.9

Correlation Matrix of A, P, K, E, M, and T
(All for n=198, except A-P-K interrelationships where n=202)

	A	P	K	E	M	T
A	1.000	0.227**	0.205**	0.108	0.121*	0.117*
P		1.000	0.271**	0.161*	0.251*	0.163*
K			1.000	0.100	0.063	0.188*
E				1.000	0.200*	0.270*
M					1.000	0.381*
T						1.000

* significant at & = .05

** significant at & = .05 and discussed in Sections 4.4.3, and 4.4.5

factors probably lead toward more opportunities and interest in participation in the curriculum development process.

It is interesting, but not surprising, to note that K is virtually unrelated to E or M. Information about the latest developments can rarely be presented in an up-to-date way in education classes, much less so in mathematics content classes. Of course, this is even more clear when the typical teacher completed his academic training several years ago, before the newest programmes were conceived. Also, the large proportion of foreign teachers who had their training abroad would have known little about Nigerian curricula from their training. However, K is much more closely linked to T: longer experience in teaching may bring teachers greater familiarity with current programmes, more chances to learn of new programmes, and perhaps greater personal efforts at seeking out more information.

Finally, E, M, and T are all quite closely interrelated with each other. In many cases, respondents obtained their training in education and mathematics in the same course, especially the Nigerian Certificate of Education (NCE). Probably the connections of T-and-M and T-and-E result from greater commitments to teaching which may result from further training.

4.6.3 Analysis by Nationality

The average scores of the three major variables (A, P, and K) and the three personal factors (E, M, and T), sorted by nationality group, are shown in Table 4.10. A total of eleven nationalities were represented in this sample: people from Bangladesh, Canada, Egypt, Ghana, India, Ireland, Pakistan, Philippines, Sri Lanka, and Sudan, and of course Nigeria. For the purposes of tabulation, they were grouped as follows:

Nigeria - Nigeria

Mid East-South Asia - India, Pakistan, Bangladesh, Sri Lanka, Egypt

Far East - Philippines

Europe - Ireland, Canada

Other Africa - Ghana, Sudan

For each of the six variables, the means for each of the five nationality-groups were calculated. The means of the five nationality-groups can be compared pairwise in ten different combinations for each of the six variables, making a total of sixty difference-of-means checks. The test statistics for each of these was calculated and checked for significance. More details are given in Appendix G.

Table 4.10

Average Scores on the Six Variables, by Nationality Group

National Group	A	P	K	E	M	T	Number
Nigeria	71.9 (7.3)*	3.0 (2.5)	2.9 (3.7)	2.1 (0.4)	1.9 (0.6)	5.8 (4.9)	78 (39%)**
Mid East, South Asia	71.8 (6.7)	3.6 (2.3)	2.9 (3.0)	2.3 (1.5)	3.3 (0.6)	13.6 (7.7)	70 (35%)
Far East	73.9 (8.2)	4.2 (2.6)	2.1 (2.9)	3.1 (0.6)	3.2 (0.5)	14.1 (6.2)	38 (19%)
Europe	70.7 (4.5)	2.0 (1.4)	7.0 (4.9)	3.0 (0.0)	2.3 (0.5)	11.0 (8.8)	3 (2%)
Other Africa	73.3 (5.4)	3.6 (2.5)	5.3 (4.8)	1.8 (0.9)	2.1 (0.6)	8.6 (3.8)	9 (5%)
Overall	72.3 (7.2)	3.5 (2.5)	2.9 (3.5)	2.4 (1.1)	2.7 (0.9)	10.4 (7.4)	198 (100%)

* for the variables, the bracketed numbers are the standard deviations

** for the numbers, the bracketed numbers are the percentages out of the total (198)

Note: all data is rounded to the nearest tenth; percentages to the nearest whole percent

Among the main variables (A, P, and K), none of the differences of means were significant at $\alpha = .05$. The comparisons of means of the personal factors showed more significant differences. Generally, the Nigerians and Other Africans were significantly lower than the non-Africans in Education-level and the Mid East-South Asia and Far East teachers were significantly higher than all the others in Mathematics-level. This is to be expected as Ministries of Education hire many Nigerian NCE-holders, but would be unlikely to take foreigners without degrees. All the expatriate groups had significantly longer ($\alpha = .05$) averages than Nigerians in teaching experience, and also the two Asia groups' averages were significantly longer than the Other Africans. Apparently, most foreigners gain some years of teaching experience at home before venturing to other countries.

Of particular interest to the present study is that the major variables, A, P, and K, showed few differences among the national groups. The qualifications and teaching experience may in some sense be national characteristics; e.g., most foreigners obtain a degree before coming to Nigeria while the largest group of Nigerian teachers are NCE-holders. But it appears that attitude toward new curricula, knowledge of new curriculum contents, and participation in curriculum development cut across national identities, and are more a matter of individual interest and inclination.

4.7 Opinions

The Attitude scale of the present study (see Part A in the sample of the instrument, Appendix D) consists of twenty statements for the respondents to indicate their degree of agreement. In a sense, this was also an opinion poll on issues relating to curriculum development and implementation. As such, the item-by-item responses show the thinking of the teachers polled on these issues. Each of the average item-scores is given by the item in Appendix D. Some of the items are mentioned here for their interesting results.

The strongest positive responses of the twenty items, 4.38 on the scale of 1 to 5, was a tie between items 16 and 20. Item 20 was perhaps over-obvious in its intent such that few teachers would disagree with it. It said, "Even though it means more work, I enjoy the challenge of teaching new material in mathematics". Item 16, "I am eager to attend familiarization meetings to learn about new mathematics curricula", had the same highly positive score of 4.38. This seems to show a desire on the part of teachers to keep abreast of the new developments. Note that this agreement represents all the responding teachers; not just those who actually did attend one of the experimental workshops. This supports the more formal statistical results by indicating that workshops to disseminate new curricula would be well-received.

Item 15 came close to the overall item-mean of 3.6. Its score was 3.78 which is between "neutral" and "disagree" on this negatively-worded item. It says, "Considering the extra work involved, I would refuse to start teaching a new syllabus in mathematics without some financial incentive". It seems that the respondents were shy to demand financial incentive, but certainly would not refuse anything that was offered.

Considering the openness claimed in Item 20 (mentioned above) and other similar items, the score of 3.03 for Item 14 was surprisingly low. The item is: "Even if a new syllabus for mathematics hasn't been officially introduced, I try it in my own classes". Perhaps this fairly low score corroborates the lack of knowledge shown in the K scores, since a teacher cannot try a new curricula unless he knows what it is. Alternatively, this may show a sense of docile obedience - a fear to go beyond the officially sanctioned material.

The two least favourable items were both negatively-worded statements that the respondents agreed with. Item 5, "I feel more comfortable teaching material in mathematics which I've taught before", had a score of 2.60 (between "agree" and "neutral"). Perhaps this simply shows the streak of conservative indolence in most teachers. Maybe the key word is "comfortable": moving easily in familiar paths. (However, it it is interesting to see the similar but more specific statement in Item 13 - "I prefer staying with the older programme in mathematics because I already have lessons planned for that" - met with disagreement: a score of 4.05. Apparently, even though familiar material is more comfortable, the image of using the same old lesson notes year after year repels most teachers.)

The most negative statement response of all was to Item 19. The score of 2.06 represents agreement with the statement: "Communication is often lacking from mathematics curriculum planners to the mathematics teachers." That statement and the response it received summarizes a major theme of this study: Communication is lacking; and the question arises: What can be done to open more channels of communication?

4.8 Summary of Data Analysis

The major points of the data analysis can be summarized as follows:

(1) Hypothesis 1 is rejected. There is a significant positive correlation between the teachers' scores on Participation and Attitude.

(2) Hypothesis 2 is rejected. There is a significant positive correlation between the teachers' scores on Knowledge and Attitude.

(3) Hypothesis 3 is rejected for the experimental group while the same comparison shows no significant change for the control group. There is a significant gain in Knowledge scores from the pre-test to the post-test for the group which attended the experimental workshop, but no significant change for the group which did not attend the workshop.

(4) Hypothesis 4 is rejected for the experimental group; those who attended the experimental workshop showed a significant positive *gain* in their Attitude scores. For the control group the hypothesis of no change is also rejected, but this group, which did not attend the workshop, shows a significant *decline* in their Attitude scores.

(5) There was no significant change in any of the variables for either group between the post-test and the third administration of the test, through the experimental group suffered slight (non-significant) drops in all three variables.

(6) Partial correlations and regression analysis indicate that participation plays a larger explanatory role than Knowledge in the Attitude scores.

(7) Personal factors of levels of training in education and mathematics, and years of teaching showed some significant correlations to the major variables, though the clusters of A, P, and K among themselves and E. M, and T among themselves showed greater correlations.

(8) National groups showed small, always non-significant differences among the major variables, but some significant differences among the personal factors.

(9) Opinions from the Attitude items showed teachers being cautiously willing to try new programmes in school mathematics but feeling a serious communication breakdown between curriculum developers and classroom teachers.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary of the Project

5.1.1 Areas of Research

This research, studying the effects of teacher participation in mathematics curriculum development on the implementation of the resulting curriculum, sought information from several different sources and was carried out in correspondingly different modes. All sources made important contributions to the findings. For convenience of discussion, these areas of research will be labelled (a) historical, (b) theoretical, (c) statistical, and (d) experiential (A similar breakdown is suggested in Section 3.1). The work in each of these areas is summarized in the following sections (5.1.2, 5.1.3, 5.1.4, and 5.1.5, respectively; and then the resultant findings are discussed in the same categories (in Sections 5.2.2, 5.2.3, 5.2.4, and 5.2.5, respectively).

5.1.2 Historical Research

The historical research of this project was the review of mathematics curriculum development and implementation efforts of the past, discussed in detail in Section 2.2. Early ideas and developments in mathematics curricula were briefly summarized, followed by a more detailed account of curriculum developments since the 1950s in various parts of the world. Then the programmes of school mathematics in Africa, and especially in Nigeria, since 1960 were described, with special attention given to the most recent syllabuses (Federal Ministry of Education (1977)) and the associated work in curriculum development and implementation.

The historical review was intended to serve two purposes: (a) to provide background to the development of the present curriculum, the implementation of which is the immediate concern of this study; and (b) to point out cases of curriculum development in mathematics where classroom teachers have participated to greater or lesser extents, thus providing (i) comparisons of the amount of participation of teachers in the present programmes, and (ii) examples to support conclusions and recommendations on teacher participation in curriculum development.

5.1.3 Theoretical Research

The theoretical research of this study continued the review of literature from the historical summary, but with the focus shifted to academic studies of the processes of curriculum implementation. This review is in Section 2.3. Included were descriptions of various models which have been offered as explanations of the curriculum implementation process and findings from case studies of implementation. The review then focussed on the role of the classroom teacher in implementation. Also, some of the few studies of this topic in West Africa were briefly discussed.

The review of theoretical research was intended to (a) provide guidelines for the experimental part of this project - (i) suggestions to aid in the organization and content of the experimental workshops for their greater effectiveness, and (ii) methodological ideas for the experimental design and the construction and content of the instrument; and (b) to provide a theoretical basis for the findings from the statistical data, their interpretation, and the resulting conclusions and recommendations.

5.1.4 Statistical Research

The statistical part of this study was a case study which included the testing of the following four hypotheses, stated below in null-hypothesis form:

> Hypothesis 1: There is no significant correlation between the teachers' levels of participation in the curriculum development process and their favourable attitudes toward the introduction of the resulting curriculum into the schools.
>
> Hypothesis 2: There is no significant correlation between the teachers' levels of knowledge about the goals and content of the new curriculum and their favourable attitudes toward the introduction of the curriculum into the schools.
>
> Hypothesis 3: There is no significant change in the teachers' knowledge of the goals and content of the new curriculum after attendance at a three-day curriculum familiarization workshop.
>
> Hypothesis 4: There is no significant change in the teachers' attitude toward the introduction of a new curriculum into the schools after attendance at a three-day curriculum familiarization workshop.

The variables and other terminology of these hypotheses and the overall organization and procedures of the experimental statistical part of the study are reported in Chapter 3 and the analysis of the resulting data is in Chapter 4.

A fifty-item instrument was developed to use in testing the four hypotheses by giving (a) a measure of the respondent's participation in curriculum development work; (b) a measure of the respondent's knowledge of the content and philosophy of the particular curriculum currently being introduced; and (c) a measure of the respondent's attitude toward accepting new curriculum. The respondents were mathematics teachers in teachers' colleges of Benue, Kaduna, and Sokoto States. The instrument and the case are described more fully in Sections 3.3 and 3.4.

There were two major kinds of statistical results: correlational and pre-test - post-test.

The correlations were used to test Hypotheses 1 and 2 (stated above; see also Section 1.3, 4.4.2, and 4.4.3) to find out if any relationship existed between the attitude and participation scores and between the attitude and knowledge scores.

After the first administration of the instrument, an experimental group of teachers attended a special workshop, designed to familiarize them with the new mathematics curriculum for teachers' colleges, and to give them an opportunity to assist in the further development of the curriculum. The teachers who were not invited to the workshop, constituted a control group. After the workshop, the same instrument was again administered to all the teachers. The differences in the respondents' scores from before the workshop and from after the workshop were compared to test Hypotheses 3 and 4 (stated above; see also Sections 1.3, 4.5.2, and 4.5.3), regarding the effects of attendance at the workshop on the attitude and knowledge scores.

Further statistical analyses were made, including the investigation of the relationships between personal factors (level of training, length of teaching experience, nationality) and the main variables, and the interrelationships among the personal factors (Section 4.6).

The statistical research was intended - as was the historical and theoretical research - to study the participation of classroom teachers in the development of new mathematics curricula and the effect of this participation - or, at least, of familiarization - on the implementation process, and in particular, on the teachers' support of the changeover to the new programme. However, unlike the historical and theoretical aspects of the project, the statistical research was directed specifically to the immediate case of implementing the new mathematics curriculum in the teachers' colleges of northern Nigeria.

5.1.5 Experiential Research

The experiential aspect of this study was the part which was most directly practical in (a) giving the researcher field experience with curriculum implementation and especially in the organization of curriculum familiarization workshops; and (b) assisting with the current campaign to familiarize teachers with the new syllabus for mathematics in teachers' colleges (Federal Ministry of Education (1979)) and to develop textbooks and other curriculum materials to meet the requirements of this syllabus.

The main part of this work was the organization of a series of workshops - first, a pilot workshop, and then one in each of Benue, Kaduna, and Sokoto States. The particular research purpose of the workshops was to serve as the experimental treatment for the statistical study. As such, the workshops were conducted between the first and second administrations of the instrument and the respondent scores from the first and second administrations were compared. This part has been referred to immediately above in Section 5.1.4 on statistical research.

Besides the use of the workshops as the experimental treatment, the planning, arranging, organizing, and presentation of the workshops provided valuable professional experience which may be useful to other workshop organizers. Details of this experience are reported in Chapter 3, mainly in Section 3.5. The arrangements included the planning of the workshop content and activities, preparation of materials, coordination of the logistics of informing and accommodating the participants, and working with the appropriate officers of the State Ministries of Education.

The experience of this professional and organizational activity contributed to the findings of this study, especially in giving recommendations for future workshop programmes and for the policies of curriculum implementation in northern Nigeria.

5.2 The Findings

5.2.1 Types of Findings

The four aspects of this research project, as described in Section 5.1 above, produced four complementary types of findings: (1) historical trends and examples, (2) theoretical models and case studies, (3) statistical survey and experimental results, and (4) practical experiences. Each contributed in its own way to the final conclusions on the participation of teachers in mathematics curriculum development and implementation (Section 5.4) and to the resulting recommendations (Section 5.5). However, before comprehensive conclusions and recommendations were made, the findings from each of the four types of research in this project were collated and are reported in the following four Sections 5.2.2, 5.2.3, 5.2.4, and 5.2.5.

5.2.2 Historical Findings

5.2.2.1 Learning from History: The review of the history of mathematics curriculum development and implementation (Section 2.2) provided the context in which present curriculum work is carried out. History shows that past curriculum developers have often faced similar problems which seem to recur over the decades. By studying the earlier solutions, modern educators should benefit from ideas for dealing with such problems.

Similarly, various forces are always acting on the mathematics curriculum, pulling its emphasis in one direction or another. Some of these forces are beyond the control of teachers or curriculum developers, even outside the realm of education. Economic and societal forces and demands can pull the curriculum out of the hands of educators, as was seen in the 1930s (Section 2.2.2.3). Developments in mathematical research and innovations in psychology (Section 2.2.2.3) and other fields closer to mathematics education also exert pressure on school mathematics. (The present writer discusses the changes in these forces elsewhere (Shirley (1980a)), suggesting that they follow a cyclic pattern.) Even if some of these forces may seem beyond the control of educators and classroom teachers, it remains imperative, as Howson (1978) suggests (Section 2.2.5.4), for them to be aware of the effects of these changes and to shape mathematics curricula and instruction appropriately.

5.2.2.2 Recent Developments in Nigeria: In Nigeria, certain special factors have influenced recent school mathematics curricula and continue to be important in further curriculum development. These were described in Sections 2.2.10 and 2.2.11, but can be summarized briefly in three areas.

First the efforts toward Universal Primary Education (UPE) (Sections 2.2.10.2 and 2.2.11.3) had far-reaching effects. (a) Great expansion of primary schooling required many more teachers, especially teachers with adequate preparation to teach primary mathematics. (b) Having one-hundred percent of the children attending schools meant that the curriculum must cater to a wide range of interests, abilities, and backgrounds. (c) As greater numbers of children pass through primary school, more demand places in post-primary institutions, so a follow-up expansion occurs at the higher levels of schooling. Altogether, UPE brought the need to review curricula at all levels: primary, teacher-training, and secondary.

Secondly, the National Policy on Education (1971, 1981) (Sections 2.2.10.3 and 2.2.11.2) demanded that all curricula - including that of mathematics - should reflect national goals and aspirations. The Policy spelled out new educational structures, special goals for particular types of education, and a philosophical background for Nigerian education. New curricula must fit the structure; developers must consider the special types (e.g., education of handicapped children); and resulting programmes should help fulfil national objectives.

Finally, worldwide developments in mathematics education require interpretation in Nigerian terms (Sections 2.2.10.4 and 2.2.11.1). Nigeria was not alone in rejecting the extremes of "modern mathematics" and, as in other countries, mathematics curriculum developers in Nigeria must also avoid the other extremes of such limited "basic mathematics" curricula which preclude scientific and technological development.

5.2.2.3 Role of Teachers in Curriculum: History demonstrates that the classroom teacher is valuable in contributing to new mathematics curricula as they are being developed, and that teacher training and familiarization are important parts of successful implementation. The first major committees making recommendations on school mathematics (Section 2.2.2.1) were mostly composed of university and industrial mathematicians. But very soon (Section 2.2.2.2) classroom teachers were also participating in the deliberations. At mid-century (Sections 2.2.3.1, 2.2.3.3, and 2.2.4.2), several important committees initiated "modern mathematics", also with teachers in their memberships.

The problem of training teachers for new mathematics programmes seemed nearly ubiquitous, especially after the start of "modern mathematics" (Sections 2.2.3.1, 2.2.4.2, and others). Many programmes tested their materials in classrooms, including Entebbe Mathematics (Section 2.2.8.3) and JSP (Section 2.2.9.1) in Africa.

Workshops for familiarization and training were often organized, sometimes in chains, with workshop participants going out to conduct further workshops (Section 2.2.6.2). However, workshops as a new programme was launched were not enough: a continuing programme of teacher assistance was necessary (Section 2.2.5.3). Such continuing help was the reason for the establishment of teacher-centres and similar institutions (Sections 2.2.5.2 and 2.2.6.2).

It is more difficult to arrange to have teachers actually writing mathematics textbooks and other curricular materials. Some programmes successfully used teachers as writers (Sections 2.2.4.2 and 2.2.5.3), especially relying on teachers' first-hand knowledge of the capabilities of their students. In West Africa, JSP (Section 2.2.9.1) was initiated and written by teachers unsatisfied with other programmes. One programme which the JSP teacher-writers were rebelling against was the Entebbe Mathematics (Section 2.2.8.3). Although Entebbe used trial-testing in classrooms and arranged many workshops, most of the writing was done by mathematicians and a few school officials. Many teachers complained that the Entebbe curriculum did not fit with the realities of classrooms or the student interests and abilities, and this inappropriateness hindered the implementation of the Entebbe programme.

A mathematics curriculum development programme which seems to have made one of the best combinations of teacher-writing and teacher-training in a developing country was the Caribbean Mathematics Project (Section 2.2.6.3). Basing their work on the JSP texts (Mitchelmore and Raynor (1968-72)) (which were themselves teacher-written), teachers of varying qualifications developed teaching modules in local workshops, preparing locally appropriate and relevant materials at the same time as they learned more of the content and presentation methodologies - and they knew the results were truly their own.

5.2.3 Theoretical Findings

5.2.3.1 Difficulties of Description: The theoretical findings are derived from a synthesis of the various studies described in Section 2.3. A fundamental finding from this review is that there exist serious definitional and methodological difficulties in describing curriculum implementation and the many related aspects of this field (See Section 2.3.4.4). At a higher level than definitions, several models of the process of curriculum implementation were proposed (Sections 2.3.2.4 and 2.3.3). However, the process of introducing new ideas in education is so complex that the task of model-building seems hopeless; Dalin (1978) (Section 2.3.3.5) noted the complications and limitations inherent in any model and recommended study of cases instead.

A further difficulty of description, more practical than academic, is the difference between the formal, official statements of curriculum objectives and contents and the realities of the classrooms where the curriculum is to be implemented. Several writers called for more pragmatism and concern for realities in curriculum design (Sections 2.3.4.1, 2.3.6.2, and 2.3.7.1).

At the end of the process, there is even doubt over the meaning of "success" in curriculum development and implementation. Some "successes" may be different from the original goals of a curriculum project (Section 2.3.4.3). Also, there is a danger of measuring implementation effects too early to show lasting acceptance and success (Sections 2.3.4.4 and 2.3.7.5).

5.2.3.2 Difficulties of Implementation: The second main type of theoretical findings relates to actual difficulties encountered in implementing new curricula. Some of these problems result from the definitional problems described in the previous section (5.2.3.1): if the meanings of "implementation" and "success" are not clear, it may be difficult to recognize successful implementation; or if there are too many complex factors to make a model of implementation, these many factors will also complicate and obstruct any plans to carry out the implementation.

Often, internal confusions and lack of clarity within curriculum development teams led to a lack of unified purpose and resulted in much confusion among the teachers who were expected to follow new curricula (Sections 2.3.4.2 and 2.3.4.3). Also the need was shown for clear communication and unified direction along the lines from the centre of a curriculum project out to peripheral receivers (Section 2.3.3.3).

There was emphasis on the enormous array of interrelated factors affecting the implementation of curricula - political, economic, sociological, psychological; as well as factors linked to characteristics of the school structure, the strategy of implementation, and the innovation itself (Sections 2.3.3.4 and 2.3.3.5).

Many researchers noted the need for more detailed planning and careful organization of the implementation, and for better infrastructure and facilities to handle the implementation programme. The planning and organization help to clarify more precisely what is to be done and to attempt to be prepared for the many conflicting influences on the process. Throughout all is the need for increased communication - within the project team and in reaching out to the teachers. Anything that helps to ease the flow of communication will aid the implementation.

5.2.3.3 Teacher Training and Familiarization: The most important communication in the implementation is the familiarization and training of the teachers. This finding comes from nearly all of the sources. No curriculum can bypass the teacher; rather, every effort should be made to inform the teachers and gain their support (Section 2.3.4.2). All of the models of curriculum implementation (Section 2.3.3) point to information links from the developers to the receiving teachers, e.g., Havelock's (1971) note of the "social interaction" and "problem-solving" models being easier to implement due to greater contact between the teachers and developers; and the CLER model reference to linkages and training resources.

Earlier writers (Sections 2.3.2.2 and 2.3.2.4) referred to teacher "resistance" to change as a major obstacle to implementation. However, more recently, the idea of "resistance" has been rejected (Sections 2.3.3.5 and 2.3.4.1). Rather, the hesitation of teachers has been seen primarily as a lack of familiarity or a lack of confidence, both of which can be helped with appropriate training. Hanson (1975) (Section 2.3.5.2) detected an improvement in attitudes toward educational change as knowledge of the change increased. Also, many other studies (for examples, in Sections 2.3.2.6, 2.3.6.5) pointed to adequate pre-service and in-service training as crucial to the success of new curricula.

Agreeing with the historical examples mentioned in Section 5.2.2.3, several writers (in Sections 2.3.5.5, 2.3.6.2, 2.3.6.3, 2.3.7.2, and others) found that the assistance should not only come before the introduction of a new curriculum, but must be a continuing service, offering assistance to classroom teachers in teachers'-centres or through visits of specialist advisors to give on-site suggestions to teachers at their schools.

5.2.3.4 Teachers' Contributions to Curricula: The final major finding from the literature is that the involvement of teachers with new curriculum can begin much earlier than a familiarization workshop; if teachers participate in curriculum design from the very beginning of its development, there are likely to be gains in both the quality of the curriculum and the smoothness of its implementation. Note was made of the need for more concern with the real problems of classrooms and for increased relevance to the local culture, problems of which teachers are most knowledgeable (Sections 2.3.4.1, 2.3.5.5, 2.3.6.2, etc.). Hence there were recommendations that curricula should be adjustable to the local environment and teacher abilities, with teacher input guiding the development (Sections 2.3.6.3 and 2.3.7.1). Several studies (Sections 2.3.4.4, 2.3.5.1, and 2.3.5.2) indicated strong links between the amount of teacher participation in curriculum design and the eventual success of the curriculum's implementation.

However, participation in curriculum development can be hard work and take much time. There is need to give recognition and reward for the contributions of the teachers to keep up their morale and momentum (Sections 2.3.5.5 and 2.3.6.2).

Miles (1964c) (Section 2.3.5.4) noted the seemingly contradictory tendencies of a teacher's sense of autonomy and his role as part of the educational system. However, teacher participation in curriculum development helps resolve the contradiction: his autonomous expertise contributes to the system's new curriculum. The new curriculum is not an imposition from outside. As Taylor (1981) (Section 1.1.3) argued, people who work on a new programme develop "ownership in change", feeling a part of the innovation and much more ready to support its introduction.

5.2.4 Statistical Findings

5.2.4.1 The Tests of Hypotheses: The results from the statistical analysis of the experimental and survey data from the case study are reported in Sections 4.4, 4.5, 4.6, and 4.7. A summary of the results is given in Section 4.8. This section again summarizes the results and points out major findings from this aspect of the study.

The major results are those derived from the testing of the four hypotheses.

> Hypothesis 1: There is no significant correlation between the teachers' levels of participation in the curriculum development process (P scores) and their favourable attitudes toward the introduction of the resulting curriculum into the schools (A scores).

Hypothesis 1 is rejected (See Section 4.4.2). A significant positive correlation is seen between the teachers' scores on Participation and Attitude. Those who had participated more in curriculum development and related activities tended to look more favourably upon the introduction of new mathematics curricula in the schools.

> Hypothesis 2: There is no significant correlation between the teachers' levels of knowledge about the goals and content of the new curriculum (K scores) and their favourable attitudes toward the introduction of the curriculum into the schools (A scores).

Hypothesis 2 is rejected (See Section 4.4.3). A significant positive correlation is seen between teachers' scores on Knowledge and Attitude. Those who know more about the content, approach and history of the new mathematics syllabus tend to be more willing to accept a new programme.

> Hypothesis 3: There is no significant change in the teachers' knowledge of the goals and content of the new curriculum (K scores) after attendance at a three-day curriculum familiarization workshop.

Hypothesis 3 was tested for the control and experimental groups. It is accepted for the control group and rejected for the experimental group (See Section 4.5.2). Those who attended the workshop showed a significant gain in their Knowledge scores while those who did not attend the workshop showed no significant change. It appears that the workshop participants learned more about the new mathematics syllabus at the workshop.

> Hypothesis 4: There is no significant change in the teachers' attitude toward the introduction of new curricula into the schools (A scores) after attendance at a three-day curriculum familiarization workshop.

Hypothesis 4 was also tested for both the control and the experimental groups. It was rejected for both groups (Section 4.5.3); however, the change in the Attitude scores showed a significant gain for the experimental group while the control group's Attitude scores dropped significantly. It appears that attendance at the workshop more than compensated for an otherwise decline in attitude toward accepting change in the curriculum.

In general, these results imply that those teachers who had participated in curriculum development and those who knew more about the new mathematics syllabus tended to have a more favourable attitude towards accepting curriculum change. The experimental workshop was especially designed to familiarize the participants with the new syllabus and solicit their assistance in its further development. By its nature, it automatically increased their participation in curriculum development and the results show that it also increased their knowledge. The results of testing the fourth hypothesis ties the earlier ones together by showing that as the participating teachers increased their participation and knowledge of the new curriculum, their attitudes toward accepting change also became more favourable.

It might be noted that Hypotheses 1 and 2 alone do not show causality, as all correlations only show relationships. That is, it cannot be said that increased participation causes more favourable attitude; it may be that teachers with more favourable attitudes tend to push themselves into greater participation. Similarly, teachers with favourable attitudes might seek out more information on new syllabuses and thus become more knowledgeable. However, the addition of Hypotheses 3 and 4, showing an increase in Attitude over time, while Knowledge and Participation increase as the experimental treatment, strengthen the case for causality.

5.2.4.2 Other Results Related to Hypotheses: Additional analyses, related to the tests for the hypotheses, provide further findings.

Participation and Knowledge were found to be significantly positively correlated (Section 4.4.5). Increased participation in curriculum development and increased knowledge of the new mathematics syllabus go together.

In multiple and partial correlation and regression calculations, Participation was seen to contribute more than Knowledge to increases in Attitude (Section 4.4.6). Apparently, active participation in developing curricula is more closely linked to favourable attitudes than the rather passive acquisition of knowledge about the new programmes.

A third administration of the instrument about two months after the second administration (the post-test) showed no significant changes in any of the three variables for either control or experimental groups. However, the experimental group showed slight - non-significant - declines in all three variables, following their gains in the post-test scores (Section 4.5.5). This might indicate the need for another workshop or other support for the teachers to help maintain the momentum from the experimental workshop.

5.2.4.3 Personal Factors: Measures of personal factors - training in education, training in mathematics, and experience in teaching - showed the best correlations among themselves (Section 4.6.2). Among the major variables (Attitude, Participation, and Knowledge), Participation showed the best correlation to the three personal factors; i.e., teachers with more training and those who had taught longer tended to have participated more in curriculum development; perhaps due to their greater expertise from additional training or experience.

The major variables (Attitude, Participation, Knowledge) showed virtually no differences among the various nationality groups represented in the sample.

5.2.4.4 Opinions: Responses to individual items of the attitude-scale section of the instrument served to indicate particular attitudes and opinions of the responding teachers (Section 4.7). The teachers tended to feel more comfortable using the older programmes with which they were more familiar. They showed hesitation to start using a new programme before it is officially launched. However, they were interested in the challenge of teaching new material and they seemed eager to attend curriculum familiarization workshops. Their most negative response was agreement with a statement that communication was lacking from curriculum developers to classroom mathematics teachers.

5.2.5 Experiential Findings

5.2.5.1 Practical Findings: The experience of organizing a curriculum development workshop and, generally, working with the implementation of a new mathematics curriculum yielded certain practical and professional findings, in addition to the more academic findings reported in the previous three sections. Most of these findings from the field relate to the organization of workshops and are drawn from Section 3.5.

Also, since some of these findings (especially Section 5.2.5.3) relate to the implementation of the new teachers' college mathematics syllabus (Federal Ministry of Education (1979)), they might be considered as a follow-up to the "historical" Sections 2.2.10.6 and 2.2.11.4, which refer to this syllabus and its implementation.

Note that because of the more practical nature of these findings, they lead more naturally to the recommendations (Section 5.5, especially 5.5.4) than to the conclusions (Section 5.4) of this study.

5.2.5.2 Workshop Planning and Organization: An important finding related to the organization of workshops is that good communication is important in many aspects of the work. This includes personal discussions with the authorities to make arrangements, special care in informing the participants of the workshop and inviting them to come; an adequate amount of handouts and a printed programme to assist the teachers in their participation in the workshop; and external publicity via the news media to inform the general public of the programme and its implications. Also, communication among the participants was encouraged by the organization of small discussion groups.

Also, it was found that careful planning of content and activities can not only make a workshop run more smoothly, but also that planning can make the presentation of the workshop's message more effective. A well-planned programme avoids boring delays and the embarrassment of a lack of materials. Good planning keeps the participants actively involved and helps the handling of unexpected problems.

A further finding related to the workshops is that Educational Resource Centres (ERCs), or similar facilities with different names, now exist in several states of northern Nigeria. Two of the experimental workshops (those of Kaduna and Sokoto States) were held in such Centres, the pilot administration of the instrument was done at a workshop held in Niger State's ERC, and it was learned that several other states also have similar facilities. These ERCs can provide good venues for workshops with meeting rooms, assistance for production of visual aids, and kitchen facilities. Their major shortcoming as conference centres is the lack of sleeping accommodation.

5.2.5.3 The Current Implementation Campaign: The experience of actually being involved in the implementation of the new syllabus in mathematics (Federal Ministry of Education, (1979)) gave the researcher an opportunity to observe the general progress of the current implementation campaign. Some of these first-hand observations contributed to the writing of Sections 2.2.10 and 2.2.11.

It was found that many teachers in the schools were still (in late 1981) unaware of the existence of a new syllabus. Few had seen the printed copy of the syllabus and it seems that these printed copies are extremely limited in number and difficult to obtain. It should be noted that one of the handouts given to all participants at the experimental workshops was a complete copy of the syllabus.

Similarly, news of current developments in the implementation efforts is rarely forthcoming, except to those directly involved. The researcher was surprised to learn of text modules being prepared to cover the Teacher Education syllabus. This news came from a participant at one of the workshops who had been asked to help prepare some of the modules. Also the progress of the "Further Mathematics" syllabus development was not heard of until a copy of a draft syllabus appeared nearly a year after it was prepared.

Some communication and diffusion has taken place in various workshops. In 1979 there were several familiarization workshops for various areas of the nation, to inform teachers of the new Teacher Education syllabus at about the time it was formally approved. Again, in late 1981, the Federal Ministry of Education organized some workshops on a multi-state regional basis.

Niger State, and perhaps a few others, organized state-wide workshops with similar goals. However, in each of the three states of the study, the experimental workshop, organized by the researcher, was the first, and so far the only, workshop for bringing the new syllabus to classroom teachers.

The rather low average score for the Knowledge (K) variable (Section 4.3.2), measured more than two-and-a-half years after the formal approval and announcement of the syllabuses, is another indication of the slow diffusion of information about the new curriculum.

5.3 Methodological Problems

5.3.1 Non-Experimental Difficulties

5.3.1.1 Problems: As in all research, there were certain problems in conducting this study. Some caused delays in the work and some made the study less comprehensive than was desired. However, as is described below, it appears that none have seriously affected the major results of the study.

5.3.1.2 Finding Information: An initial and continuing problem was the difficulty in finding and obtaining source materials, especially research from West Africa and Nigeria in particular. This lack of research (and the need for more) has already been mentioned (Section 1.4.4) as a part of the justification for this study. Also the difficulty and the attempt to surmount it are discussed in Sections 2.3.6.1 and 2.4.1, where some sources of information are described. However, a comprehensive bibliographic directory of educational research in Nigeria (or West Africa) is still an unmet need of serious scholars.

Part of the difficult task of obtaining information is related to the content of this study and has been mentioned in the experiential findings (Section 5.2.5.3). News about current developments in school mathematics and curriculum implementation is often available only by chance, even for mathematics educators, publishers, and others who could be making useful contributions.

5.3.1.3 Arranging Workshops: A second problem area, which has also been discussed above (Sections 3.5.2, especially 3.5.2.3; and 5.2.5.2), concerns the arranging of the series of experimental workshops. The distance involved (especially for Benue and Sokoto States, since the researcher was based in Kaduna State) made it difficult to check on the progress of the arrangements - the invitations, the venue and facilities, the plans for the opening ceremony, and other details. However, eventually, some postal communications, notes carried by hand, and personal visits got the messages through and the workshops were held on schedule with few problems.

5.3.2 Problems in Data Collection

5.3.2.1 Coordinating Administration: The same kind of distance and communication problems that hindered the workshop planning also made it difficult to coordinate the administration of the instrument to collect the data (See Section 3.4.5). In all three states of the study, the researcher personally administered some of the questionnaires, but he was also aided by one research assistant in each state. All were well-qualified (all were graduates; two were M.Ed. students) and reliable, and all did their jobs well, but still the task of distributing copies of the instrument to them, clarifying the timing of the three rounds of administration, and collecting the completed questionnaires was more difficult than anticipated, especially for the two more-distant states, Benue and Sokoto.

5.3.2.2 Benue State Problems: In Benue State, the research assistant became seriously ill during the post-test administration. A last-minute substitute (another M.Ed. student) was called upon to help out, and also the researcher made an unplanned trip to Benue to complete the administration.

A further problem in Benue State data collection (and workshop planning) was caused by the state's schools opening late (mid-October) because of the state government's financial difficulties. This allowed less time for the school visits to contact the teachers for the pretest. Hence, the number of respondents for the first round in Benue State was less than anticipated. However, it must be noted that the small number from Benue also reflects the fact that Kaduna and Sokoto States each have about twice as many teachers' colleges as Benue State.

The smaller number of respondents from Benue appears to have made the data from that state more dispersed and probably less reliable. (See Tables 4.3, 4.4, 4.6, and 4.7 in Sections 4.3 and 4.4). However, these do not seem to be major problems in the interpretation of the results. The mean Attitude score for Benue was midway between Sokoto and Kaduna scores, not at an extreme (Table 4.5). More important, the correlations of the variables from Benue data were all in the same directions as the rest of the data, varying for the most part in level of significance only.

5.3.2.3 Lack of Teacher Cooperation: In all three states, it proved to be impossible to reach every mathematics teacher in every school, especially to reach every teacher in all three administrations of the instrument. Often, a school principal would report a given teacher, for various reasons, was not at school that day. When the teacher was present, he might be busy with his classes. If the researcher (or assistant) left copies of the questionnaire at the school, he often returned to find them still uncompleted or lost. Sometimes it was impossible to return to a given school due to limited travel time to cover the itinerary.

Sometimes teachers did not want to complete the questionnaire at all, as four pages, fifty items, or a request for information on qualifications seemed to make some hesitate to cooperate. This was especially true on the second and third administrations, for teachers would argue that they had already completed the questionnaire once or twice before. This is similar to the methodological problem reported by Ozumba (1974) and Shipman (1974) (Section 2.4.2).

5.3.2.4 Result of Smaller Samples: The main result of this incomplete data collection was that the sample size is smaller than anticipated. However, for the testing of the four hypotheses, the sample size was still quite adequate for reliable statistical treatment.

For the correlation tests of Hypotheses 1 and 2, the results by individuals had n=202 (Sections 4.4.2 and 4.4.3) The pre-test - post-test results, used for testing Hypotheses 3 and 4, required teachers to have both pre-test and post-test results, so the numbers were more limited, but even with this restriction, the experimental group had n=35 and the control group had n=44, so it was not even necessary to use t-tests rather than z-tests (Sections 4.5.2 and 4.5.3). Only for the checking of "retention", which used the data from the second and third rounds of administration, were the numbers below thirty (n=9 for the experimental group; n=15 for the control group), requiring the use of the t-distribution. However, this test was an extra result, beyond the main hypotheses of the study (Section 4.5.5.).

5.3.3 Problems of Statistical Analysis

5.3.3.1 Instrument: There are several places where errors can enter into any statistical analysis. This section reviews these potential problem-areas for the present study; however, it will be seen that none of them caused serious difficulties.

The instrument was developed with considerable care, with concern for high validity and reliability of its measurements. The content of the items was drawn from early research studies and practical experience (See Section 3.4.2) and the language, format, and balance of the items were chosen to direct the respondents' thinking to the immediate responses being measured (See Sections 3.4.1 and 3.4.2). The validity was checked and confirmed by experienced classroom mathematics teachers and an expert on the construction of attitude scales and questionnaires (See Sections 3.4.4.1 and 3.4.4.2).

A pilot version of the instrument was administered and the results subjected to item analysis (See Sections 3.4.3 and 3.4.4.2). The final instrument was based on the results of the item-analysis and the previous recommendations.

Split-half analysis of the actual final results of the attitude scale yielded a reliability coefficient which was considered quite adequate for attitude measurements (See Section 3.4.4.3).

5.3.3.2 Scoring and Calculation: The scoring was done entirely by the researcher himself, often double - and triple-checking, and using a template to avoid errors. The attitude item scores were all re-checked as they were loaded into the computer for the reliability test.

The calculations were all done on a ZX81 micro-computer. All calculation programs were checked on a small scale before they were run with the entire data set, to make sure they yielded the kind of results that were intended. Also, it often happened that the same results could be extracted from the calculations of various different programs. Identical results calculated with different methods in such cases confirmed their accuracy.

Scoring and computer work are described in Sections 3.6 and 4.3.

5.3.3.3 Group Selection: The method of selection of members of the experimental group, i.e., those who were invited to attend the workshops, was not entirely under the control of the researcher and hence he cannot claim that the selection was random. However, a variety of *ex post facto* tests showed virtually no differences between the two groups; difference-of-means z-tests and **tests of** F-ratio-of-variances of the three major variables and the three personal factors, and a difference-of-proportion test on nationality proportions, all yielded very satisfactory results to show the similarity of the two groups (See Section 3.3.3.2).

5.3.3.4 Generalizability: This research was a case study of data collected from three states of northern Nigeria: Benue, Kaduna, and Sokoto States. Hence the results apply only to these states. However, similarities and commonalities in historical development of education and in administrative structures of education, throughout the northern part of Nigeria, and indeed, throughout English-speaking West Africa, and perhaps other former British colonial areas, might allow cautious generalization of the results to all of these areas (Section 3.3.2.6).

5.4 Conclusions

5.4.1 Reference to the Findings

Section 5.2 reports the major findings of this study, based on the results of the literature survey, the conduct of the experimental workshops, and the analysis of the data. This present section draws conclusions from the findings. No specific references are made here, but supporting evidence and references to earlier parts of this study are given among the findings in Section 5.2.

5.4.2 Early Participation of Teachers in Curriculum Development

All **areas** of this study point to the value of early participation of classroom teachers in mathematics curriculum development. The theoretical writings note that the sense of pragmatism that teachers bring from their classroom experience, as well as their closeness to local culture, can make the resulting programmes more appropriate for the realities of their intended use. Several examples from the recent history of mathematics curriculum development demonstrated the same point, showing cases of teachers writing curricular material and teachers testing new programmes in classroom trial use, leading to improvements in quality.

The statistical data showed that favourable attitude toward change in mathematics curriculum was positively correlated to the amount of previous participation in curriculum development. Also, attitudes became more favourable after additional participation from attendance at a curriculum development workshop. Furthermore, active participation in curriculum development was seen to contribute more to a favourable attitude than passive knowledge of the new programme.

These results agree with the reports in the theoretical literature which note that participation gives a sense of ownership of the curriculum to teachers, greatly increasing their support for the resulting programme. The historical cases showed considerable success for programmes which had involved teachers in the planning and preparation and counter-examples of programmes that had little teacher input and were not so successful.

Also the reports showed that teachers who are directly involved in developing a curriculum become well-acquainted with its goals, content, and approach, and hence much more competent in using it in the classroom. This teacher-training role of early teacher participation is especially important in areas where there is a shortage of qualified teachers.

5.4.3 Familiarization Workshops

Early active participation in mathematics curriculum development has been seen as desirable. However, even if that cannot be arranged, at the very least, teachers should be made aware of the new programme and become familiar with its content and approach well in advance of its formal introduction. A familiarization workshop can be very useful in achieving this awareness.

The data analysis showed significant gains in knowledge about the new curriculum and in attitude toward accepting change in the mathematics curriculum following attendance at a familiarization workshop. Knowledge of the new programme was positively correlated with attitude toward accepting the curriculum change. Also, teachers showed high interest in attending curriculum familiarization workshops.

These findings were strongly supported by the literature. Nearly all the writers pointed to the need for training and familiarizing teachers with new curricula and workshops were noted as an effective way of disseminating new programmes. Worldwide, adequate teacher-training has been one of the major requirements for successfully introducing new mathematics programmes. Workshops were often used for this purpose - singly, in chains, or as a part of continuing programmes of teacher training and assistance.

However, the present project found that in this area, few workshops had been organized and many teachers were not yet aware of the new mathematics curriculum.

5.4.4 Communication

Throughout this study, the need for increased communication in mathematics curriculum development and implementation was evident. Greater clarity, smoother flow, and more opportunities for the exchange of information and ideas among teachers, Ministry of Education officials, and curriculum developers are required for improved programmes and easier implementation.

The experimental data shewed the value of better information flow as teacher attitudes toward changes in the curriculum were shown to be more favourable when the teachers were more knowledgeable of the new programme. But also, the responding teachers strongly agreed that there was a lack of communication from mathematics curriculum planners to classroom teachers.

The theoretical and historical literature pointed to three areas where communication can improve curricula and ease their implementation: (1) Teachers should make suggestions, based on their own experience, to improve curriculum design; (2) curriculum developers should keep teachers (and others) well informed on the goals and content of new programmes, on the progress of the development, and on the strategies of the implementation; and (3) within a curriculum development team, all should strive to clarify the objectives of the project and to work for greater unity of purpose.

5.4.5 Teacher Centres

A special conclusion must be made about teacher centres. Teacher centres were seen to serve as focal points for early teacher participation in curriculum development; as venues for familiarization, training, and writing workshops; and, generally, as communication centres for exchange of ideas among teachers, curriculum developers, and Ministries of Education. Beyond the basic development and implementation of curricula, teacher centres can make teaching aids, expert advice and assistance, and other instructional resources more easily available to teachers and, thus, help to improve the overall quality of education.

The literature review noted the successes of teacher centres and similar institutions in various countries, and several writers called for increased establishment and use of such centres.

Several states in northern Nigeria have made a start in establishing teacher centres by opening Educational Resource Centres (or similar centres under different names) and three were involved in the conduct of this research. However, they seem to be under-utilized and not yet numerous enough to be easily accessible to all teachers.

5.5 Recommendations

5.5.1 Source

The following recommendations are offered, based on the overall experience of this research project, in hopes of providing assistance for further work, academic and practical, in the areas of this study. The recommendations are mainly drawn from the experiential findings (Section 5.2.5), the problems of methodology (Section 5.3), and the conclusions (Section 5.4). However, they in fact reflect all parts of the study, even including the original justifications for the present work (Section 1.4), for the justifications remain valid for further study in this area.

5.5.2 Methodological Recommendations

(1) There is great need for a clearinghouse of educational research in Nigeria (or West Africa in general), probably in the form of a regularly up-dated bibliographic reference, including annotations or abstracts.

(2) Further study of curriculum implementation requires greater standardization of terms such as "implementation", "adoption", and the steps in the implementation process.

(3) Future studies of a similar nature to this present work might gain from (a) working with a smaller geographical area; and (b) making the instrument more palatable to respondents, especially in multiple administrations, perhaps by reducing the size and putting it in different formats for different administrations.

5.5.3 Recommendations from the Conclusions

(1) Curriculum developers should make more efforts to involve classroom teachers in mathematics curriculum development from the start of the process. This may include encouraging teachers to make suggestions, obtaining information on local culture from teachers, using teachers as writers, and testing draft materials in classroom trials.

In particular, the teachers who participated in workshops of the present project made many suggestions for the content and presentation of the syllabus for teachers' college mathematics. The notes from their work are available from the researcher for potential use in the preparation of textbooks or other curricular material.

(2) Ministries of Education and the Nigeria Educational Research Council should organize more workshops to try to reach every teacher for familiarization with new mathematics programmes (in particular, the 1979 mathematics syllabuses for all levels of schools). Workshops should be well-planned, should have varied programmes, should keep the participants actively involved, and should be held in a series over a long period to maintain continuing contact with the teachers.

(3) Every state, or preferably every zone, should establish at least one Educational Resource Centre. On a more local level, every town or every group of nearby schools should have a small mathematics teacher centre. The former (ERC) should include full facilities for workshops, including rudimentary sleeping accommodation, perhaps like a hostel. The mathematics teacher centres could be one room, or even a corner of a room, with cupboards and shelves for mathematics reference books and instructional materials. Ministries of Education should post mathematics specialists to each ERC, and they should visit mathematics teacher centres or individual teachers at their schools regularly and often to provide assistance and to exchange ideas.

5.5.4 Recommendations on Practical Details

(1) A regular (perhaps quarterly) newsletter should be issued by the Federal Ministry of Education for exchange of information on all aspects of mathematics curricula and school mathematics in general.

(2) Efforts for the implementation of the 1979 mathematics syllabuses should be increased. As a first step, copies of the appropriate syllabus should be made available to all mathematics teachers. Familiarization workshops should be organized at local levels to reach all teachers (as recommended above) and samples of textbooks and other teaching materials should be made available for teacher perusal. The mass media may also be used to acquaint the general public with the new programmes.

(3) Everyone involved in curriculum planning should have greater concern for the realities of the school situation: in stating goals and objectives, in considering student abilities and needs, in using available resources, and in describing programmes. Given the serious shortage of qualified Nigerian mathematics teachers, an important part part of this reality is the need to develop more qualified teachers and retain them in the profession, a need which is probably greater than further curriculum development.

5.5.5 Recommendations for Further Research

(1) Further analyses might be made of the data of the present research, such as item-by-item analysis of responses to the participation and attitude scales, further comparisons between the main variables and the personal factors, or more complex multivariate studies. The researcher will make available the original returned questionnaires and computer tapes of the attitude item responses and the overall combined data matrix (A, P, K, E, M, T, and nationality; by individual for each round of administration; sorted by state and control/experimental group) to anyone wishing to make further analysis.

(2) Further study is necessary on the complex process of implementation of new curricula, especially case studies. Especially valuable would be study of implementation at a later stage in the process than was studied in the present work. In particular, follow-up studies could be made of the same curriculum and the same sample as was investigated by this study, to record the longitudinal progress of the implementation. Also, similar studies in other developing nations would be helpful in generalizing the results of the present work.

(3) Further research is needed in mathematics curriculum and overall mathematics education in Nigeria, West Africa, and, more generally, the developing nations of the Third World. Study is needed to learn more of such areas as: (a) better teaching approaches; (b) improved curricula, such as more relevant and practical mathematics content; (c) the local culture, history, and traditions of mathematics, and how they can be related to school mathematics; and (d) objective histories and evaluations of recent school mathematics programmes.

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APPENDIX A

Letter to Ministries of Education

The following is a general draft of the letters sent to the Ministries of Education of Benue, Kaduna, and Sokoto States (See Section 3.5.2.2). Specific details were filled in for each state as appropriate.

Department of Education
Ahmadu Bello University
Zaria

10 August 1981

The Permanent Secretary
_____ State Ministry of
Education

____

________ State

Dear Sir,

Workshop on Mathematics in the Teachers' Colleges

I am a Senior Lecturer at Ahmadu Bello University and Head of the Mathematics Education Section in the Department of Education.

I am currently conducting research which I believe can prove very beneficial to education in _____ State, not only in its final results, but even in the experimental study itself. I have several requests for your assistance with the research project.

(1) I would like to organize a workshop for approximately thirty mathematics teachers from the teachers' colleges of _____ State. The workshop would probably be on a Thursday,

Friday, and Saturday, in late October or early November, with the exact dates chosen to fit the Ministry's calendar. The workshop would help to implement the new Teacher Education Mathematics Curriculum, recently approved by the Federal Government, by (a) familiarizing the teachers with the new syllabus; and (b) recruiting their assistance in designing materials for textbooks and teaching aids so that forthcoming texts and aids would really reflect input from classroom teachers.

I hope you could assist me with the workshop in the following ways:

i. grant permission for the workshop to be held;

ii. release the invited teachers from their teaching responsibilities for three days to allow them to attend; and, in fact, require their attendance at the workshop as part of their job;

iii. provide the participating teachers with appropriate overnight allowance and travel allowance;

iv. issue certificates of attendance to the workshop participants;

v. provide a suitable room in which to hold the meetings of the workshop, as well as related facilities and equipment (e.g., overhead projector, tape cassette player, kitchen facilities for the refreshments, chairs, tables, etc.); and

vi. give each participant a file-folder in which to keep his papers from the workshop.

On my part, I would supply:

i. all expertise and organization for the content and activities of the workshop;

ii. all handouts and related papers (including copies of the new syllabus) for all participants;

iii. all posters, overhead projector transparencies, and other display materials;

iv. supplies for refreshments to be served at the breaks;

v. (perhaps) a light lunch for the Thursday and Friday meetings (but this would have to be confirmed later);

vi. evening "entertainment" programmes - still with content related to mathematics education; and

vii. a special certificate of attendance if a Ministry certificate is not possible.

(2) The research aspect of this project makes it necessary for me to ask all mathematics teachers in the teachers' colleges to complete a confidential questionnaire relating to their attitudes and knowledge of the new programme in mathematics and their past involvement in its development. I wouldlike to survey the teachers in September before the workshop, in November after the workshop, and probably once more in January or February. I would like all teachers to complete the questionnaire - both those who attend the workshop and those who do not.

The main theme of this research is to strengthen the link between classroom teachers and curriculum development and implementation. The study should help find ways to make teachers generally to feel more involved with curriculum development efforts. More specifically and directly, the workshop I propose to organize should assist the Ministry in the immediate task of preparing the teachers and the materials for smooth and successful launching of the new Teacher Education Mathematics Curriculum and the general improvement of mathematics education in the State.

I do hope you will be able to give me full cooperation.

Thank you.

Yours faithfully,

Lawrence Shirley

cc: Inspector for Mathematics, Ministry of Education,

_____ State

APPENDIX B

List of Teachers' Colleges
(Benue, Kaduna, and Sokoto States, 1981)

Benue State

Government Teachers' College, Adikpo

Government Teachers' College, Adoka

Government Teachers' College, Aloma

Government Teachers' College, Ankpa

Government Teachers' College, Ayangba

Government Teachers' College, Dekina

Government Teachers' College, Idah

Government Teachers' College, Makurdi

Government Teachers' College, Mkar

Government Teachers' College, Otukpo

Government Teachers' College, Utonkon

Government Teachers' College, Vandeikya

Government Teachers' College, Zakibiam

Kaduna State

Arabic Teachers' College, Katsina

Basawa Teachers' College, Zaria

Dutsin-Ma Teachers' College (UPE)

Government Day Teachers' College, Birnin Gwari

Government Day Teachers' College, Dan Kanjiba

Government Day Teachers' College, Jikamshi

Government Day Teachers' College, Kagarko

Government Day Teachers' College, Makarfi

Government Day Teachers' College, Malumfashi

Government Day Teachers' College, Mani

Government Day Teachers' College, Matazu

Government Day Teachers' College, Yarkasuwa

Manchok Teachers' College (UPE)

Teachers' College, Daura

Teachers' College, Kaduna

Teachers' College, Kafanchan

Teachers' College, Kagoro

Teachers' College, Katsina

Women's Teachers' College, Kabomo (UPE)

Women's Teachers' College, Kaduna

Women's Teachers' College, Katsina

Women's Teachers' College, Zaria

Women's Teachers' College, Zonkwa

Zaria Teachers' College (UPE)

Sokoto State

College of Arts and Arabic Studies, Sokoto

Giginya Memorial College, Sokoto

Government Teachers' College, Argungu

Government Teachers' College, Bakura

Government Teachers' College, Binji

Government Teachers' College, Birnin Yauri

Government Teachers' College, Bunza

Government Teachers' College Chafe

Government Teachers' College, Dogon Daji

Government Teachers' College, Gusau

Government Teachers' College, Kaura Namoda

Government Teachers' College, Maru

Government Teachers' College, Sokoto

Government Teachers' College, Tambawal

Government Teachers' College, Wasagu

Government Teachers' College, Wurno

Government Teachers' College, Zurmi

Government Teachers' College, Zuru

Halilu Abdu Teachers' College, Birnin Kebbi

Sultan Abubakar College, Sokoto

Women's Arabic Teachers' College, Gusau

Women's Teachers' College, Brinin Kebbi

Women's Teachers' College, Bodinga

Women's Teachers' College, Kangiwa

Women's Teachers' College, Yelwa

APPENDIX C

Pilot Instrument

Note: The pilot version of the instrument had the Attitude and Participation items mixed and all items had a common five-point response scale. Respondents were to write the number of their response in a blank space following each item. Here the response space is replaced by an analysis of each item according to the following key:

1. A or P to indicate Attitude or Participation item.
2. A number, 1 to 10, to indicate the subcategory of the item, using the number code of the subcategories given in Section 3.4.2.1 (for Attitude) and Section 3.4.2.2 (for Participation).
3. P or N to indicate Positive or Negative direction of the item.
4. A number, -7 to 44, to indicate the discrimination index from the item analysis. This is the difference of the total scores of the Low group from the total scores of the High group for each item. For Attitude items, the High and Low groups were the groups of 18 respondents who had the highest overall scores and the 18 who had the lowest overall scores. For Participation items, the groups had 16 members each.
5. The number of the item in the final version of the instrument (Appendix D) or - if the item does not appear in the final version.

The Knowledge scale was also included in the pilot instrument, but is not included in this Appendix as it was not changed in the final instrument. See Appendix D for the Knowledge scale. The original pilot instrument was printed on foolscap paper and hence was arranged slightly differently than is seen here. The content and development of the instrument are reported in Section 3.4; Section 3.4.3 especially discusses the pilot test and its analysis.

TEACHERS AND NEW MATHEMATICS CURRICULA - A QUESTIONNAIRE

This questionnaire is attempting to find out how well and in what way new developments in school mathematics curriculum spread out to those who are most directly involved in using the mathematics curriculum - the teachers of mathematics. We hope to use the results to help find ways of improving the communications both directions between teachers and curriculum developers.

Please take a few minutes of your valuable time to assist us. Try to answer each item as accurately and as honestly as possible. All replies will be kept confidential and will be analyzed only in statistical terms, so please feel free to be frank and open in your response.

Thank you very much for your assistance.

Instructions: For each item in this section, write 1, 2, 3, 4, or 5 in the space provided to tell how well the statement describes your own situation or your own feelings. Use the following system for the numbers you write.

1 - not at all, 2 - not quite, 3 - neutral, 4 - fairly good, 5 - very close.

Some of the questions are similar but no two are exactly alike. Read each question carefully before selecting which number best describes your situation or feelings.

1.	Even though it means more work, I enjoy challenge of teaching new material in mathematics.	A	1	P	11	20
2.	I have written to mathematics textbook publishers to give suggestions on how their books could be improved.	P	7	P	13	-
3.	Communication is often lacking from mathematics curriculum planners to the mathematics teachers.	A	4	N	11	19
4.	I regularly read journals or books on mathematics teaching to get new ideas.	P	9	P	22	-
5.	I have not served on any committee for planning change in mathematics curricula.	P	8	N	44	32
6.	It seems the new syllabus for mathematics was prepared without enough planning or discussion on what to include.	A	2	N	22	18
7.	When I see a new mathematics textbook in a shop, I buy it.	A	5	P	2	-
8.	If students perform better on exams based on a new syllabus, it demonstrates that the syllabus is of lower standard.	A	2	N	3	-
9.	I have not attended meetings of the Mathematical Association of Nigeria.	P	8	N	31	31
10.	Too often new syllabuses in mathematics are overloaded with educational theory not relevant to the classroom situation.	A	4	N	26	17
11.	I am eager to attend familiarization meetings to learn about new mathematics curricula.	A	3	P	21	16

12.	I have become acquainted with mathematics educators from all parts of Nigeria.	P	10 P	29	30
13.	I would like to try teaching new content in mathematics, but I don't have enough time to study it.	A	1 N	11	-
14.	If I learn about a new mathematics programme that seems good, I try to convince the authorities to adopt it.	A	6 P	8	-
15.	I have helped design mathematics teaching materials which will be in widespread use.	P	7 P	31	29
16.	Considering the extra work involved, I would refuse to start teaching a new syllabus in mathematics without some financial incentive.	A	1 N	17	15
17.	The best people to develop new maths programmes are the teachers who will be using them.	A	4 N	-7	-
18.	I usually first learn of curriculum changes from announcements from my principal or the Ministry of Education.	P	9 N	11	-
19.	It is easy to support a new maths programme which covers much the same content, but presents it better.	A	2 P	18	-
20.	No one will pay any attention to my suggestions for improving the mathematics curriculum.	P	7 N	9	-
21.	Even if a new syllabus for mathematics hasn't been officially introduced, I try it in my own classes.	A	5 P	26	14
22.	Other teachers usually tell me about the coming changes in mathematics curriculum.	[illegible]	9 N	-5	-

23. I doubt if a new syllabus can change the trend of low scores in mathematics exams. A 2 N 6 -

24. I resent academics telling the teachers what content should be taught in mathematics. A 4 N -1 -

25. I have served on a committee working on plans for new mathematics curricula. P 8 P 22 23

26. Attending a week-long workshop to design new mathematics curricula is more worthwhile than teaching my classes. A 3 P 10 -

27. I prefer staying with the old programme in mathematics since I already have lessons planned for that. A 1 N 19 13

28. I don't think I have the authority to make suggestions for curriculum development in mathematics. P 7 N 21 27

29. I explain new curriculum developments in mathematics to parents by meetings or printed explanations. A 6 P 9 -

30. The work involved in teaching mathematics from a new syllabus is rewarded by seeing students learn better. A 1 P 14 12

31. I have presented a paper on school mathematics at a meeting of the Mathematical Association of Nigeria (or similar conference). P 8 P 7 -

32. I sometimes feel isolated from the continuing developments in mathematics education. P 10 N 21 26

33. When it comes to accepting a new programme in mathematics, I'm not easily convinced of its value. A 2 N 8 -

34. Points of educational theory included in a new mathematics programme help me to introduce the programme more easily. A 4 P 17 -

35. I don't know who prepares new syllabuses for mathematics. P 8 N 24 25

36. Starting a new syllabus in maths gives me a good opportunity to revise my teaching methods. A 5 P 13 11

37. I want to help in curriculum development work, but so far have not been able to participate very much. P 10 N 17 -

38. If I don't like certain portions of a new curriculum in mathematics, I make modifications to reflect my own ideas. A 5 N -3 -

39. Complicated theoretical language from curriculum developers is difficult to apply to the real problems of teaching mathematics. A 4 N 6 -

40. I am sometimes surprised to learn of changes in the mathematics syllabus. P 9 N 24 24

41. I would like to try out new teaching methods in mathematics, but I don't have enough time to prepare. A 1 N 8 -

42. I would like to serve on a committee to write new textbooks for mathematics. A 3 P 36 10

43. I learn most about mathematics curriculum developments from newspapers or radio or television reports. P 9 N 9 -

44. I tell science teachers at my school about mathematics syllabus changes that relate to mathematical work in science classes. A 6 P 20 9

45. I study new material to make sure I understand any new mathematics content that I will be teaching. A 1 P 17 8

46. I attend meetings, courses, or workshops related to new developments in school mathematics. P 8 P 33 23

47. Communication is often lacking from the teachers of mathematics to the curriculum planners. A 4 N 2 -

48. I would like the opportunity to send comments on a new maths curriculum to those who are developing it. A 5 P 16 7

49. I have contributed to the writing of new textbook material in school mathematics. P 7 P 12 -

50. I am more interested in getting on with my teaching than in discussing ways the maths syllabus might be changed. A 3 N 16 6

51. I feel more comfortable teaching material in mathematics which I've taught before. A 1 N 16 5

52. I haven't had any opportunity to contribute to mathematics curriculum development. P 10 N 31 22

53. I would like to help other teachers to understand the new syllabus for mathematics. A 6 P 18 4

54. I'm not enthusiastic about new curricula in mathematics since they usually are only new arrangements of the same old material. A 2 N 13 3

55.	I have given lectures at workshops for other teachers of mathematics about curriculum developments and instruction.	P	8	P	18	-
56.	I don't want to prepare new lesson notes to cover new topics in mathematics.	A	1	N	-2	-
57.	The present poor standard of student performance in mathematics is one good reason for changing to a new syllabus.	A	2	P	13	2
58.	I contribute suggestions to appropriate authorities about improving the mathematics programme.	P	7	P	30	21
59.	If a new mathematics programme requires special teaching aids, I make special efforts to obtain what is needed.	A	1	P	8	-
60.	My contribution to new mathematics curricula would be more relevant than the contribution of a research mathematician.	A	4	N	2	-
61.	I have tried to explain the goals of the new mathematics curriculum to my students.	P	9	P	11	-
62.	I enjoy experimenting with new content or new methods in my mathematics classes.	A	5	P	15	1
63.	I find it worthwhile attending worships to learn about new syllabuses in mathematics.	A	3	P	7	-
64.	I feel like I am an active participant in the process of developing new curricula in mathematics.	P	10	P	26	-

APPENDIX D

The Instrument

Note: The actual instrument was printed on foolscap and hence was arranged slightly differently than is shown here. Section A is the Attitude scale; Section B is the Participation scale; Section C is the Knowledge scale. Further explanatory notes are given (in brackets). The final section sought personal information from the respondent. More discussion of the instrument's structure, content, and development is in Section 3.4; Section 4.3 discusses the scoring of the instrument.

TEACHERS AND NEW MATHEMATICS CURRICULA - A QUESTIONNAIRE

This questionnaire is part of a series of measurements trying to find out how well and in what ways new developments in school mathematics curriculum spread out to the classroom teachers of mathematics. We hope to use the results to help find ways of improving the communications in both directions between teachers and curriculum developers.

Probably you have completed a similar questionnaire (or even two or three) in the past few months. However, please take a few minutes of your time to assist us again. Try to answer each item as accurately and as honestly as possible. All replies will be kept confidential and will be analyzed only in statistical terms, so please feel free to be frank and open in your answers.

Thank you very much for your continuing assistance.

_____ The Teacher-Curriculum Committee, Faculty of Education, A.B.U.

Section A

Instructions: For each item in Section A, indicate how well the statement describes your own feelings. Select one of the following ratings and circle the appropriate response.

SA: strongly agree A: agree N: neutral D: disagree
SD: strongly disagree.

(Note: For this attitude scale, each item was followed by "SA A N D SD" and the respondent circled his choice, as requested in the above instructions. However, for this Appendix, the "SA A N D SD" is replaced by an analysis of each item: P or N for Positive or Negative; the subcategory number from the list in Section 3.4.2.1; and the mean item score for all questionnaires, marked from 1 to 5, with 5 as the most favourable. Note that SA for a positive item and SD for a negative item both yield a score of 5; similarly SD for positive items and SA for negative items both yield scores of 1.)

1. I enjoy experimenting with new content or new methods in my mathematics classes. P 5 4.23
2. The present poor standard of student performance in **mathematics** is one good reason for changing to a new syllabus. P 2 3.20
3. I'm not enthusiastic about new curricula in mathematics since they usually are only new arrangements of the same old material. N 2 3.50
4. I would like to help other teachers to understand the new syllabus for mathematics. P 6 4.16
5. I feel more comfortable teaching material in mathematics which I've taught before. N 1 2.60
6. I am more interested in getting on with my teaching than in discussing ways the syllabus might be changed. N 3 3.29

7. I would like the opportunity to send comments on a new curriculum in maths to those who develop it. P 5 4.01

8. I want to study new material to make sure I understand any new maths content that I will be teaching. P 1 4.30

9. I feel that I should inform science teachers at my school about mathematics syllabus changes that relate to mathematical work in science classes. P 6 4.05

10. I would like to serve on a committee to write new textbooks for mathematics. P 3 3.64

11. Starting a new syllabus in maths gives me a good opportunity to revise my teaching methods. P 5 3.87

12. The work involved in teaching mathematics from a new syllabus is rewarded by seeing students learn better. P 1 3.96

13. I prefer staying with the older programme in mathematics since I already have lessons planned for that. N 1 4.05

14. Even if a new syllabus for mathematics hasn't been officially introduced, I try it in my own classes. P 5 3.03

15. Considering the extra work involved, I would refuse to start teaching a new syllabus in mathematics without some financial incentive. N 1 3.78

16. I am eager to attend familiarization meetings to learn about new mathematics curricula. P 3 4.38

17. Too often new syllabuses in mathematics are overloaded with educational theory not relevant to the classroom situation. N 4 3.01

18. It seems the new syllabus for mathematics was prepared without enough planning or discussion on what to include. N 2 3.02

19. Communication is often lacking from mathematics curriculum planners to the mathematics teachers. N 4 2.06

20. Even though it means more work, I enjoy the challenge of teaching new material in mathematics. P 1 4.38

Section B

Instructions: For each item in Section B, circle TRUE or FALSE to indicate if it describes your own Participation in recent years in activities related to curriculum development in mathematics.

(Note: For these Participation items, "TRUE" and "FALSE" were printed after each item, to be circled as appropriate by the respondent. For this Appendix, these responses are replaced by the analysis of the subcategory code number, from the list in Section 3.4.2.2, and P or N for Positive or Negative.)

21. I have contributed suggestions to appropriate authorities about improving the mathematics programme. 7 P

22. I haven't had any opportunity to contribute to mathematics curriculum development. 10 N

23. I have attended meetings, courses, or workshops related to new developments in school mathematics. 8 P

24. Sometimes I have been surprised to learn of changes in the mathematics syllabus. 9 N

25. I don't know who prepares new syllabuses for mathematics. 8 N

26. I sometimes feel isolated from the continuing developments in mathematics education in Nigeria. 10 N

27. I don't have the authority to make suggestions for curriculum developments in mathematics. 7 N

28. I have served on a committee working on plans for new mathematics curricula. 8 P

29. I have helped design mathematics teaching materials which will be in widespread use. 7 P

30. I have become acquainted with mathematics educators from many parts of Nigeria. 10 P

31. I have attended meetings of the Mathematical Association of Nigeria. 8 P

32. I have served on a committee for planning change in mathematics curricula. 8 P

Section C

Instructions: The questions in Section C are measuring how well information about the new syllabus in teachers' college mathematics reaches the teachers of mathematics. Answer the questions by circling YES or NO, based on your understanding of the facts about the new syllabus. If you don't know the answer, do not guess, but circle DON'T KNOW. Each sentence begins with the same phrase, which is only written at the start of the set of questions.

(Note: In this Knowledge section, respondents were given "YES", "NO" and "DON'T KNOW" and were to circle one. For this Appendix, only the correct answers are given; also, following the correct answer, the letter P, C, or D appears to indicate items on philosophy, content, or developmental history of the new syllabus, respectively.)

The newest mathematics syllabus for teachers' colleges...

33. .... is mainly oriented toward teaching a deeper understanding of the theory and formal structure of mathematics. NO P

34. .... tries to give a practical everyday understanding of mathematics for general use in today's mathematical world. YES P

35. .... places the major emphasis on the fun of mathematics: games, puzzles, and even maths jokes. NO P

36. .... is intended to cover mathematics up to the level of the junior secondary school. YES C

37. .... treats geometry without formal proofs of theorems. YES C

38. .... has much coverage of basic statistics. YES C

39. .... assumes that students have a good background from their primary school mathematics. NO C

40. .... includes primary mathematics teaching methodology. YES C

41. .... describes each topic with objectives, content, activities, materials, and remarks. YES C

42. .... is controversial because it is based very much on "modern mathematics" programmes. NO P

43. .... has returned to the "traditional mathematics" almost entirely. NO P

44. .... was prepared by a committee under the Nigeria Educational Research Council. YES D

45. .... was written by a group of textbook publishers and professional writers. NO D

46. .... was prepared with considerable advice from foreign educators. NO D

47. .... was worked out about eight to ten years ago. NO D

48. .... was at first rejected by the Federal Ministry of Education. NO D

49. .... was approved at a conference in Benin City. NO D

50. .... will soon be adapted into textbook form by a group of mathematics teachers and educators. YES D

(Note: The following section was on a separate page.)

GENERAL PERSONAL DATA

These questions of personal data are independent from the accompanying questionnaire. Here we are trying to collect general information about who is teaching mathematics in the teaching mathematics in the teachers' colleges. Again, all information will be kept confidential and will be used only for statistical purposes, so please respond fully and honestly. We ask for your name and school because we may need to contact you again later. Thank you for your cooperation.

1. Name (block letters, surname underlined):__________
2. School: __________
3. Nationality: __________ If Nigerian, State of Origin __________
4. Type of Appointment (tick appropriate space)

   ______ Permanent ______ Contract ______ N.Y.S.C.

   ______ Part-time.

Note: For the remaining items, tick all the responses which are the closest equivalents to your own qualifications or experience.

5. Qualifications in Education (i.e., formal coursework in Teaching Methods, Curriculum, and/or other areas of Education as a discipline)

   ______ None

   ______ Grade II Teacher's Certificate

   ______ Nigerian Certificate of Education (N.C.E.)

   ______ Diploma or Higher Diploma in Mathematics Education

   ______ Education as a Subsidiary in a B.A. or B.Sc. degree

   ______ B.Ed. or B.A.(Ed) or B.Sc.(Ed)

   ______ M.Ed. or M.A./M.Sc. in Education

   ______ Ph.D. in Education

6. Qualifications in Mathematics (tick levels of mathematics content passed):

   ______ less than O-level Mathematics

   ______ Maths at O-level or WASC

   ______ Maths at A-level, HSC, Diploma in Maths Educ, or N.C.E.

   ______ Mathematics at Bachelor's degree level (B.A., B.Sc., B.Ed.)

   ______ Post-Graduate Mathematics

7. Teaching Experience: type of school number of years

primary school _____ years
secondary school _____ years
teachers' college _____ years
- your present school _____ years
other schools _____ years
(specify type:____________________)

Once again, thank you for your time.

APPENDIX E

Evaluation of "Practice" Workshop

(Note: Prior to the three experimental workshops, a "practice" or trial workshop was held to make sure the various parts of the programme were appropriate and would proceed smoothly (See Section 3.5.2.1). The participants at the "practice" workshop, who were all experienced teachers and students of the part-time B.Ed. (Mathematics Education) degree, completed the following evaluation form. Items 1, 2, and 3 are on their personal background. The remaining items are questions of evaluation of the workshop. Comments (in brackets) are inserted to report the responses of the participants and the effect of these responses on the actual workshop programme.)

CURRICULUM DEVELOPMENT WORKSHOP
TEACHERS EDUCATION MATHEMATICS CURRICULUM
EVALUATION FORM August 1981

1. What subjects do you teach? (in your regular job) tick all that apply)
   - Special or Optional Maths ______
   - Mathematics ______
   - Arithmetic Processes ______
   - Primary Maths Methods ______
   - Science subjects ______
   - other subjects ______
2. Do you teach at a: (tick whichever applies)
   - Secondary School ______
   - Teachers' College ______
   - Other (specify) ______________

3. Have you attended other workshops for: (tick any that apply)

familiarization of new curricula ______
writing new material for maths curric. ______
teaching methods/teaching aids ______
other (briefly specify) ______________________

4. Please use the scale below to indicate your reaction to the various aspects of the workshop

1———————2——— 3——— 4———— 5
unfavourable neutral favourable

a.	general lectures and discussions	1 2 3 4 5
b.	work in large Topic Group	1 2 3 4 5
c.	work in small Suggestion Group	1 2 3 4 5
d.	arrangement of the schedule	1 2 3 4 5
e.	arrangement of the groups	1 2 3 4 5
f.	opportunity to express your ideas	1 2 3 4 5
g.	opportunity to compare ideas	1 2 3 4 5
h.	opportunity to apply ideas from Strategies class	1 2 3 4 5
i.	handouts	1 2 3 4 5

(Note: only item b. received an unfavourable rating; the large Topic Group discussions were removed from the programme.)

5. What part of the programme was most valuable to you? (Note: the small suggestion groups and group reports received the most favourable comments; these were emphasized in the latter workshops.)

6. What part of the programme was least valuable to you? (Note: the large topic groups received the most complaints; as stated above, they were dropped.)

7. If you could add one other type of item to the programme, what would it be? (Note: There was little response to this item. The biggest request was for demonstration of teaching strategies and talk on selected topics. This was somewhat removed from the actual purpose of the workshop; however, it was partially covered in the report sessions when some groups demonstrated their suggestions.)

8. If you could make one other improvement to the Workshop, what would it be? (Note: The most common response was to request more time for work in the small groups; others asked for more reference books to be available; also more group report and discussion time was requested. For the actual workshops, more books were made available and the times for group work and discussion were slightly expanded within the limits of available time.)

9. Has this workshop made you more interested in the new curriculum? Yes Neutral No

10. Do you feel more knowledgeable about the new curriculum?
Yes Neutral No

11. Do you feel more eager to see the new curriculum in use?
Yes Neutral No

(Note: Items 9, 10, and 11 were overwhelmingly favourable.)

12. Any other comments? If so, write them on the back - including explanations for any of the above items. Also, feel free to discuss the Workshop with me. Thanks very much.

(Note: Again, the major comments were to ask for more working time and/or fewer topics to be covered to allow more detailed discussions. As noted above, attempt was made to satisfy this request. One person said this type of workshop should be held nation-wide at the local government level. That is for the various Ministries of Education to note.)

APPENDIX F

Workshop Programme

(Note: The participants at the Workshops each received a programme, printed in the form of a small booklet. The pages of the booklet are approximately reproduced in this Appendix.)

(cover)

CURRICULUM
DEVELOPMENT
WORKSHOPS

BENUE STATE	Government Teachers' College, Otukpo 28, 29, and 30 October, 1981
KADUNA STATE	Curriculum Development and In-Service Training Centre, Zaria 5, 6, and 7 November, 1981
SOKOTO STATE	Extension and Support Services Division, Sokoto 25, 26, and 27 November, 1981

Sponsors: The Ministries of Education of Benue State, Kaduna State and Sokoto State

Coordinator: Lawrence Shirley, Mathematics Education Section, Department of Education, Ahmadu Bello University, Zaria.

TEACHER EDUCATION MATHEMATICS CURRICULUM
Federal Ministry of Education, Lagos, 1979

(page 1)

TO THE PARTICIPATING TEACHERS:

Welcome to the Curriculum Development Workshop for the Teacher Education Mathematics Curriculum!

The new syllabus for mathematics in the teachers' colleges has been approved and published by the Federal Ministry of Education, and will soon be coming into full use. However, a syllabus is really only the skeleton of a curriculum. Before the curriculum can be completely ready for classroom use, it needs additional materials - especially textbooks, and suggestions for teaching aids - and even more important, it needs teachers who are familiar with the new programme and its objectives, content, and mode of presentation. This workshop will attempt to help bring the curriculum more smoothly and successfully into the classrooms, by trying to

(a) familiarize you with the new syllabus, and

(b) recruit your assistance in designing materials for textbook and teaching aid development so that forthcoming texts and aids will really reflect input from classroom teachers.

Who else knows your class and its interests and abilities better than you? Who else but you can offer curriculum suggestions which are truly appropriate and relevant for your own students? We hope you can contribute very much to this important workshop. That's why we invited you!

Thanks in anticipation for your most helpful service.

____ the Workshop Planning Committee

(pages 2 and 3; centre-spread)

Curriculum Development Workshop

PROGRAMME

Wednesday, 28 October
FIRST DAY Thursday, 5 November
Wednesday, 25 November

9:00 Registration
10:00 Opening Ceremony
11:00 Break
11:30 "The New Philosophy in the Teachers' College Mathematics Curriculum" - L. H. Shirley
12:15 An overview of the syllabus
Assignment of Topics for further discussion
1:00 Lunch Break
3:00 Methodology in the new syllabus: Discussion and suggestions
4:55 Announcements
5:00 Dinner Break
7:30 Evening Programme: "Number Lattices"
An approach to arithmetic through play
- L. Shirley (courtesy David Page)

Thursday, 29 October
SECOND DAY Friday, 6 November
Thursday, 26 November

8:30 "Algebra" and "Geometry/Measurement" in the new syllabus
9:00 Small groups - suggestion writing
10:00 Break
10:30 Small groups - more suggestions, consolidation
12:30 Lunch Break
2:30 Group reports and discussion
4:00 "Number", "Statistics", and "Inference" in the new syllabus
4:55 Announcements
5:00 Dinner Break
7:30 Evening Programme: "Metaphors and Analogies on Gödel's Theorem", an illustrated, tape-recorded programme, on mathematical logic. - Douglas Hofstadter

Friday, 30 October
THIRD DAY Saturday, 7 November
Friday, 27 November

8:00 Small groups - suggestion writing
10:00 Break
10:30 Small groups - more suggestions, consolidation
11:00 Group reports and discussion
12:30 Closing remarks - A Challenge
1:00 Final Adjournment

(page 4)

SOME ADDRESSES - for more ideas and information
- to send further suggestion and comments

Agencies and Organizations

Federal Ministry of Education:
Educational Services Division, PMB 12573, Lagos
Nigeria Educational Research Council (NERC), PMB 8058, Lagos

Mathematical Association of Nigeria (MAN), c/o The Secretary
Dr. Idowu, Mathematics Dept., University of Jos, Jos

(British) Association of Teachers of Mathematics (ATM)
Market Street Chambers, Nelson, Lancs., BB9 7LN, U.K.

(American) National Council of Teachers of Mathematics (NCTM)
1906 Association Drive, Reston, Virginia 22091 USA

Publishers of Textbooks (incomplete; can you add more?)

Aromolaran Publishing Co., Ltd., P.O.Box 1800, Ibadan

Evans Brothers (Nigeria Publishers), Ltd., PMB 5164,
Jericho, Ibadan

Heinemann Educational (Nigeria), Ltd., PMB 5205
Ighodaro Road, Jericho, Ibadan

Longman Nigeria, Ltd., PMB 21036, Ikeja, Lagos

Macmillan Nigeria Publishers, Ltd., P.O. Box 1463, Ibadan

Thomas Nelson (Nigeria), Ltd., PMB 21303, Ikeja, Lagos

Onibonoje Press and Book Industries (Nigeria) Ltd.,
P.O.Box 3109, Ibadan

Oxford University Press (Nigeria), Ltd., Iddo Gate,
PMB 5095, Ibadan

APPENDIX G

Statistical Techniques

A variety of statistical tests were employed in this study. In this Appendix, they are briefly described and the appropriate formulae are given.

Ordinary correlation tests measure linear relationships between two variables - the degree that one variable tends to increase (or decrease) as the other increases. The formula for the Pearson product-moment correlation coefficient is derived from the product of the differences of the individual values of each variable from their means, taken in pairs and summed over all the data points. The formula is adjusted so that the resulting coefficient ranges from +1 (perfect correlation), through 0 (no correlation), to -1 (perfect inverse correlation). The usual calculation formula is:

$$r_{xy} = \frac{(n\Sigma xy - \Sigma x \Sigma y)}{\sqrt{(n\Sigma x^2 - (\Sigma x)^2 (n\Sigma y^2 - (\Sigma y)^2)}}$$

Tests of hypotheses of $r = 0$ rely on the fact that the sampling distribution of r is normal and symmetrical around zero. The standard error of r is $\sigma_r = \frac{1}{\sqrt{n-1}}$, (where n is the sample size), so this leads to a test statistic of:

$$z_{calc} = \frac{r - \rho}{1 / \sqrt{n-1}}$$

In all cases of this study, $\rho = 0$, so $z_{calc} = r \sqrt{n-1}$

For a given α, the chance of wrongly rejecting a null-hypothesis, z_{α} is the value of z such that α is the proportion of the unit area under the normal curve which is beyond z, measured outwards from $z = 0$. The appropriate value of z_{α} can be found from the standard tables of values of the normal distribution. If $|z_{calc}| > |z_{\alpha}|$ the null-hypothesis of $\rho = 0$ can safely be rejected with a confidence of $1 - \alpha$, and r is said to be significantly positive (or negative) at a level of α.

Ordinary correlation tests are used in this study to test Hypotheses 1 and 2 (Section 4.4) and to check the relationships among the personal factors and between each of them and each of the main variables (Section 4.6.2). Also, the reliability of the attitude scale was checked (Section 3.4.4.3) by the split-half technique, which involves measuring the correlation of the score from the even-numbered items and the score of the odd-numbered items, based on the reasoning that in a reliable test, the scores on the two halves should be closely matched. To counteract for lower correlation that tends to come with smaller numbers of data points (here from only taking ½n pairs of the test items), the Spearman-Brown formula (Ferguson (1981)):

$$\text{reliability} = \frac{2r}{(1 + r)}$$

is used to enhance the pure correlation result.

For paired data of independent and dependent variables, a linear regression line is the line which shows how a value of the dependent variable could be predicted from a given value of the independent variable, with the least error. Its derivation is based on making the sum of the **squares of** the errors a minimum, where the error of the i-th data pair is:

$$(\text{the predicted } y_i) - (\text{the observed } y_i).$$

The regression line's equation is:

$$\text{predicted } y = B_o + B_1 x$$

$$\text{where } B_1 = \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

and $B_o = \bar{y} - B_1\bar{x}$ (with $\bar{y}$ and $\bar{x}$ as the means of the y_i and x_i, respectively)

By a similar derivation, a multiple linear regression line can be calculated to show the prediction of y from several dependent variables $x_2, x_3, \ldots x_k$. The case used in this study is that of two dependent variables. For this case, the equation of the regression line is:

$$y = B_1 + B_2x_2 + B_3x_3$$

with $B_2 = \dfrac{r_{12} - r_{13}r_{23}}{1 - r_{23}^2} \cdot \dfrac{s_1}{s_2}$

$$B_3 = \frac{r_{13} - r_{12}r_{23}}{1 - r_{23}^2} \cdot \frac{s_1}{s_3}$$

and $B_1 = \bar{y} - B_2\bar{x}_2 - B_3\bar{x}_3$

with r_{12} = the correlation coefficient between y and x_2

r_{13} = the correlation coefficient between y and x_3

r_{23} = the correlation coefficient between x_2 and x_3

s_1 = standard deviation of y

s_2 = standard deviation of x_2

s_3 = standard deviation of x_3

and $\bar{y}$, $\bar{x}_2$, and $\bar{x}_3$ are the means of the y_i, x_{2i}, and x_{3i}, respectively.

Using these same values, the coefficient of multiple determination, or multiple correlation coefficient, which like the correlation coefficient described above, shows the degree of relationship of the variables, can be calculated from:

$$R_{1.23} = \sqrt{\frac{r_{12}^2 + r_{13}^2 - 2r_{12}r_{13}r_{23}}{1 - r_{23}^2}}$$

Also in the case of y, x_2, and x_3, partial correlation can be calculated. Partial correlations $r_{12.3}$ and $r_{13.2}$ show the correlation between one independent variable, x_2 or x_3, and the dependent variable, y, while the other independent variable, x_3 or x_2, is held constant.

$$r_{12.3} = \sqrt{\frac{R^2_{1.23} - r^2_{13}}{1 - r^2_{13}}}$$

$$r_{13.2} = \sqrt{\frac{R^2_{1.23} - r^2_{12}}{1 - r^2_{12}}}$$

It should be noted that other formulae may be used for these values, but these are especially useful in the present study because they use the simple correlation coefficients, which had been calculated earlier.

The regressions and partial correlations are used in finding further relationship between the dependent variable A and the independent variables P and K in Section 4.4.6.

Besides the hypothesis testing of correlations, several other tests of hypotheses and general tests of significance were carried out. For each, the standard error has been derived and the test statistic is found by dividing the value being tested by the standard error. As described above, u_α is found for a given α to determine the boundaries of the critical region.

The test statistics used in this study are as follows:

Mean difference When pairs of linked data (e.g., pre-test and post-test scores) are being tested, the difference d between values in each of the pairs is found ($d_i = x_{i2} - x_{i1}$), and the mean $\bar{d}$ of these differences and their standard deviation s_d are calculated. Then the test statistic is:

$$t = \frac{\bar{d}}{s_d \sqrt{n}}$$

If $n \leq 30$, the Student t distribution for $n-1$ degrees of freedom ($df = n-1$) is used. If $n > 30$, the normal distribution is used. This test is used in the testing of Hypotheses 3 and 4 and some related analysis (Sections 4.5.2, 4.5.3, 4.5.4, and 4.5.5).

Difference of means When two independent samples, numbering n_1 and n_2, are being tested to see if their population means are the same, their sample means $\bar{x}_1$ and $\bar{x}_2$ and their standard deviations s_1 and s_2 are calculated separately. Then the test statistic is:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}\right)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

The degree of freedom $df = n_1 + n_2 - 2$. As before, Student t distribution is used if $df < 30$; otherwise, the normal distribution is used. This test is used in checking the fairness of selection into the experimental group by testing differences of means of all six variables of the study (A, P, K, E, M, and T) between the experimental and control groups, using their pre-test data (Section 3.3.3.2); and also in comparing differences of means for all six variables in all the possible combinations of nationality groupings (Section 4.6.3).

Difference of proportions When checking to see if given proportions p_1 and p_2 of two samples of n_1 and n_2 are the same population proportion, the overall proportion $p = \frac{p_1 n_1 + p_2 n_2}{n_1 + n_2}$ is calculated. Then the test statistic is:

$$z = \frac{p_1 - p_2}{\sqrt{p(1 - p)\ \frac{1}{n_1} + \frac{1}{n_2}}}$$

As long as $p_1 n_1$, $p_2 n_2$, $(1-p_1)n_1$, and $(1-p_2)n_2$ are all larger than 5, the normal distribution is used. This test is used to show that, based on the proportion of Nigerians in the experimental and control groups, the two groups represented the same population (Section 3.3.3.2).

One further comparison test is the **test of** F- ratio of variances (i.e., the ratio of the squares of standard deviations). Usually the hypothesis is that the ratio is 1. If the calculated ratio is not beyond a critical value above 1, the hypothesis is accepted. The calculation is:

$$F = \frac{s_1^2}{s_2^2}$$, where s_1 and s_2 are the standard deviations

and $s_1 > s_2$

The critical value of f is found from tables of the F-distribution, for two values of the degrees of freedom, $n_1 - 1$ and $n_2 - 1$, where n_1 and n_2 are the samples sizes of the groups whose standard deviations are s_1 and s_2, respectively. The test is also used in comparing the control and experimental groups in Section 3.3.3.2.

Further discussion and derivations of the statistical techniques described in this Appendix can be found in various statistics textbooks. The main references for this study were Yeomans (1968) and Glass and Stanley (1970).

Resume

Lawrence Hoyt SHIRLEY

Birth: 13 November 1947 in Flagstaff, Arizona, U.S.A.

Education:

Secondary: Westwood High School, Mesa, Arizona, U.S.A., 1965

B.Sc.(Mathematics and History), California Institute of Technology, 1969

M.Ed.(Comparative Education), University of Illinois, 1973

Ph.D.(Curriculum and Instruction in Mathematics Education), Ahmadu Bello University, Zaria, Nigeria, 1984

Professional Experience:

1969-1971: Mathematics teacher(Peace Corps Volunteer), Bonthe Secondary School, Bonthe-Sherbro, Sierra Leone

1971-72: Modern Mathematics Advisor(Peace Corps Volunteer), Bo, Sierra Leone

1974-present: Lecturer, then Senior Lecturer and Head of the Mathematics Education Section, Department of Education, Ahmadu Bello University, Zaria, Nigeria

Family:

Wife: Alberta Ohenewah Shirley

Children: son: Jefferson Kodwo Robert Shirley(born 1976)
daughter: Emily Abena Juliana Shirley(born 1981)
step-daughter: Takyiwaah Affie Adisi(born 1965)

Hobbies: astronomy, history, music, swimming